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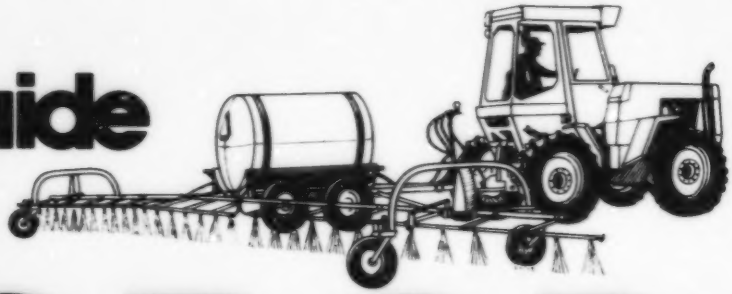

CROP PROTECTION in Alberta

PART 3
PESTICIDE APPLICATION EQUIPMENT

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GUIDE TO CROP PROTECTION IN ALBERTA

PART III PESTICIDE APPLICATION EQUIPMENT

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Introduction

The use of pesticides requires that all application equipment be of the best quality available and be used correctly.

Incorrectly applied pesticides may result in a waste of the pesticide, poor or no weed control, crop damage or environmental contamination. Every effort must be made to apply pesticides correctly to help eliminate these undesirable results.

Recent advances in equipment technology make the job of accurate pesticide application relatively simple.

This publication provides information that will aid in the selection and use of application equipment, so that pesticides may be applied as accurately as current technology allows.

Since 1981, all pesticides are supplied and labelled in metric measure. All labels are made in terms of litres of formulated product per hectare or in the case of dry materials, in kilograms of product per hectare.

Alberta Agriculture maintains land measure in acres. This publication lists application volumes in litres or kilograms per ACRE.

This will necessitate converting pesticide label information. The following conversion factor is supplied to assist in this conversion:

Litres or kilograms per hectare x 0.4047 = L or kg per acre.

Alberta Agriculture's "Blue Book" publication *Guide to Crop Protection in Alberta – Part I – Chemical* is written using acres and is compatible for use with this publication without conversion.

Spray Tips

- Know your chemicals: read the labels carefully to determine which is the right one for your crops.
- Know your crops: especially the stage that will tolerate the chemical you use.
- Know your problems: make sure that the weeds and insects you have are susceptible to the chemicals you plan to use.
- Know your timing: if it isn't right for one chemical it may be for another.
- Be prepared to invest in quality equipment: there's no sense spraying with worn out equipment that is worth a fraction of the chemical you are using.
- Pump output should be checked to ensure it produces the required volume for spraying and agitation of the spray solution in the tank.
- Check pressure in the boom to ensure there is no restriction in the flow to the nozzles.
- Ensure all nozzles on the boom are the same size and spray angle.
- Check nozzle spray patterns. Clean or replace nozzle tips that have streaky spray patterns.
- Check the output from all nozzles on the boom using a calibration cup or some other measuring device. Output from the nozzles should be within five per cent of each other.
- Liquid filled pressure gauges will prevent the gauge indicator from fluttering. The gauge will be easier to read and will remain accurate longer.
- Adjust boom height in the field so that the spray pattern from one nozzle overlaps 30 per cent into the pattern of the adjacent nozzle above the target. The target is the ground for soil applied herbicides and the average weed height for post-emergent herbicides.

MEANS YOU SHOULD WEAR:
VERY DANGEROUS PESTICIDE
COVERALLS, GLOVES, GOGGLES AND RESPIRATOR
MEANS YOU SHOULD WEAR:
SOME DANGER IN THIS PESTICIDE
COVERALLS, GLOVES AND GOGGLES
MEANS YOU SHOULD WEAR:
NOT TOO DANGEROUS PESTICIDE
COVERALLS AND GLOVES

Figure 1. What the pesticide label means

Operator and Environmental Safety

Protective Clothing

Everyone who handles pesticides should read the label on the container carefully and wear the standard protective clothing to avoid potential health hazards.

Pesticides include herbicides, insecticides and fungicides. The standard protective clothing that is recommended is:

- a long-sleeved shirt
- full-length pants
- overalls
- unlined neoprene or rubber gloves
- rubber boots
- a wide-brimmed hat.

Cloth or leather gloves, leather shoes or sneakers, or a baseball cap should never be substituted for the standard protective clothing listed above because they absorb chemicals and will expose the wearer to the chemicals.

In some cases, goggles and a respirator are recommended for people handling pesticides. Goggles, or a face shield, protect the eyes and the face against pesticide vapors, dust and splashes. A respirator will prevent the inhalation of dust, powders and sprays.

A respirator covers the nose and mouth and contains a charcoal cartridge as well as a filter pad to filter out dust and spray particles. The risk of a health hazard from using pesticides will be greatly reduced if the respirator cartridge is changed after eight hours of use or when the wearer detects a chemical odor.

Anyone who has handled pesticides should shower and change clothing when the operation is finished.

The above information, plus information on laundering pesticide-contaminated clothing, is contained in a publication entitled *Protective Clothing for Use with Pesticides* (Homedex 1353 - 90). It can be obtained from District Home Economists or by writing to

Publications Office,
Alberta Agriculture,
J.G. O'Donoghue Building,
7000 - 113 Street,
Edmonton, Alberta, T6H 5T6.

Tractor Cab Filters

Cab filters filled with activated carbon may be useful in preventing air-borne pesticides from entering tractor cabs. Tests have shown that these filters prevented about 95 per cent of airborne pesticides from entering the tractor cab. This feature may allow sprayer operators to remove cumbersome face respirators once inside the tractor cab.

Clean Water Dispenser

A small tank of clean water on the sprayer is of great value to the sprayer operator (figure 2). Clean water can be used for washing the hands and face and as an eye wash in case of emergency. Flushing plugged screens and nozzles can also be

Figure 2. Clean water dispenser

done more conveniently. The clean water dispenser should be located as far away from the spray boom as possible. Installing the tank on the tractor would provide a supply of clean water regardless of which farming operation the tractor is involved in.

Transferring Chemicals to The Sprayer

Because pesticides are more concentrated before they are mixed with water, the greatest operator exposure is likely to occur while pesticides are being mixed.

Many new sprayers are equipped with a separate tank conveniently located for filling from the chemical container (figure 3). The chemical is transferred from this tank into the main tank while the sprayer tank is filled with water. Some

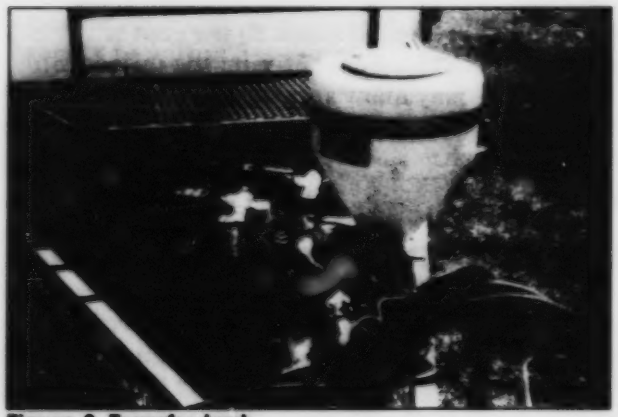

Figure 3. Transfer tank

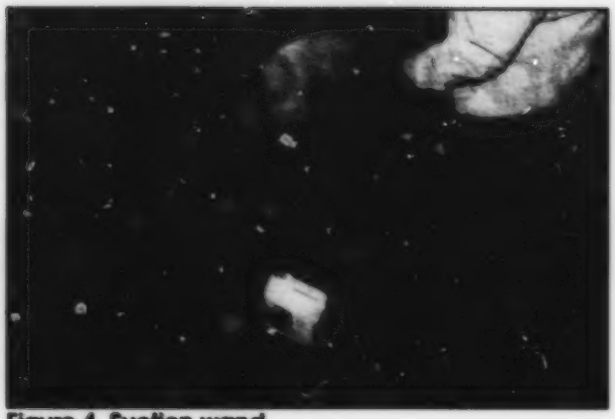

Figure 4. Suction wand

sprayers have a suction wand that can be inserted into the chemical container during the filling procedure (figure 4). The chemical is drawn into the sprayer tank while the tank fills with water.

Hand operated pumps or 12-volt pumps can also be used to transfer chemical from containers to the sprayer tank.

Container Rinsing and Disposal

Pesticide containers should be cleaned by triple rinsing or pressure rinsing. Pressure rinsing using a specially designed container rinser (figure 5) is just as effective as triple rinsing.

Container rinsers are designed for use in both metal cans and plastic jugs. The hose from a water source or from the nurse tank pump is securely attached to the rinser. After ensuring that the valve is at the "off" position, insert the sharp piercing end of the rinser into the bottom centre of the inverted metal container or the side wall (near the bottom) of a plastic container. The water under pressure can be turned on and off at your convenience and the leftover pesticide residue is rinsed into the spray tank.

When you use a can rinser there is no need to use the triple rinsing method of rinsing pesticide containers. It takes 30 seconds to rinse a pesticide container with a can rinser compared to five minutes for triple rinsing, thus saving valuable time.

Figure 5. Can rinser

A rinser renders the containers useless for any future use by puncturing them and reduces potential health and environmental hazards.

Empty containers must be disposed of in a safe manner. In Alberta there are centralized sites where all types of pesticide containers are collected for recycling.

Disposal of Excess Pesticide

Proper planning and measuring should ensure that there is little excess chemical. When a pesticide solution is left over, one can spray the solution on a summerfallow field at the same rate it was applied to the crop, provided the chemical will not adversely affect future crops that will be grown on the summerfallow. Excess solution can also be temporarily stored in the original containers in an area inaccessible to children and animals.

Sprayer Clean-up

Proper maintenance of a sprayer will result in longer sprayer life and increase the hours of trouble free operation. Consult the operator's manual for proper maintenance procedures.

At the end of each spraying day, the tank should be thoroughly rinsed with clean water. Clean water should then be flushed through the pump, booms and nozzles. Plugs at the ends of the boom should be removed to thoroughly flush the boom. All nozzle screens and filters should be checked and cleaned if necessary. Use a soft brush or compressed air to clean nozzle tips.

A more complete cleaning of the sprayer is required when changing from one chemical to another, especially when the crop to be sprayed is sensitive to the previous chemical.

If an ester formulation of 2,4-D or MCPA has been used last, proceed as follows:

1. Drain the sprayer and flush with clean water.
2. Rinse the tank and the rest of the sprayer with diesel fuel or kerosene. Use a scrub brush extended on a stick or broom handle to wash the inside of the tank. Do not use a mop, because threads that fall off can cause plugging problems.
3. Rinse the sprayer with a strong detergent solution to remove the oil. Grease the pump after using cleaning detergent. Continue on to step 4.

To remove amine or salt formulation, start here:

4. Circulate clean water through the entire sprayer.
5. Thoroughly drain the sprayer, then partially fill the tank with clean water and add one part household bleach for every 100 parts water.
6. Circulate the solution through the entire sprayer.
7. Allow the solution to remain in the tank over night.
8. Recirculate, and drain the sprayer. Rinse the sprayer thoroughly with clean water and drain.

Some chemicals have specific sprayer cleaning instructions. Check product labels for specific cleaning information.

Choose the cleaning area carefully to ensure that streams, wells, dugouts or underground water courses are not contaminated.

Sprayer Storage

When preparing the sprayer for storage the following points should be considered:

1. Thoroughly clean the sprayer. Drain it completely, especially the filters, pressure regulator, selector valve, gauges and booms.

2. Flush the entire sprayer with an automobile antifreeze containing a rust inhibitor.
3. Check the sprayer for worn parts and make a list of all components that need replacement. Order the parts well before the next spraying season.
4. If storage is for the winter months, remove the pump and follow the manufacturer's storage recommendations.
5. Seal off all openings in the sprayer.
6. Store the sprayer in a location where it will not be damaged by other equipment or livestock. Polyethelene tanks should be stored under cover to prevent deterioration by sunlight. Galvanized steel tanks should be stored away from moisture to prevent rusting.

Drift Control

Types of Drift

Pesticide drift is the movement of pesticide from target to off-target areas. This can result in costly crop, insect or environmental damage in off-target areas. Two types of pesticide drift can occur; (1) droplet drift occurs at the time of spraying when smaller droplets remain airborne and are carried downwind. This is the most common type of drift and usually the most damaging. (2) vapor drift occurs following deposition of the pesticide on the crop or soil surface. The pesticide may then begin to evaporate, releasing vapor into the air, which drifts downwind for considerable distances. Since vapor drift is primarily controlled by a chemical property known as volatility, there is little the farmer can do to reduce it, except to use non-volatile or low-volatile formulations. Spraying when a period of cool weather is expected may reduce vapour drift, but this is normally not a very practical measure.

Droplet drift can be controlled by a variety of practical measures. However, some measures taken to reduce droplet drift can result in reduced pest control. Thus, a careful balance must be struck between controlling drift and obtaining adequate pest control.

In conventional sprayers, droplets are produced by hydraulic pressure. Water under pressure is forced through an orifice and spreads into a sheet of liquid. As the liquid travels from the nozzle, it breaks into thin sheets called ligules, which in turn break into droplets. Very large droplets may break into small droplets before the target is reached.

The most desirable droplet size for any spray application depends on the pesticide being applied, the nature of the spray target and the environmental conditions at the time of application. Insecticides and fungicides normally require very small droplets (less than 150 microns) to maximize the surface contact area. Post-emergence herbicides usually require droplets of 150 microns to 400 microns size. Smaller droplets are subject to off-target drift, and larger droplets tend to roll or bounce off plant surfaces. Since coverage with soil applied herbicides is less critical, they can be applied with larger droplets that reduce spray drift.

The droplet sizes produced by a nozzle are affected by orifice design and size, nozzle angle and by the liquid pressure. For any given nozzle type, larger orifice nozzles will produce larger droplets, and the wider the nozzle angle, the smaller the droplet size.

Droplet size refers to the size of the individual spray droplets that comprise a nozzle's spray pattern. All of the droplets within a given spray are not the same size. These droplet sizes are usually expressed in microns (micro-metres). One micron equals 0.001 millimetres.

Volume median diameter (VMD) is a means of expressing droplet size in terms of the volume of liquid sprayed. The VMD droplet size when measured in terms of volume (or mass) is a value where 50 per cent of the total volume of liquid sprayed is made up of droplets with diameters larger than the median value and 50 per cent smaller than the median value. Because the VMD is based on the volume of liquid sprayed it is a widely accepted reference and is used in tables 1, 2 and 3.

Table 1. Effect of Nozzle Type on Droplet Size at 275 kPa (1.6 L/min)

Nozzle type	Droplet size (VMD) µm
TeeJet 80°	470
XR TeeJet 80°	460
FloodJet	450
FullJet	680
ConeJet	360

Table 2. Effect of Spray Angle on Droplet Size at 275 kPa (1.6 L/min)

Spray angle	Nozzle type	Droplet size (VMD) µm
40°	4005 Flat Spray	810
65°	6505 Flat Spray	550
80°	8005 Flat Spray	470
110°	11005 Flat Spray	380

Table 3. Effect of Flow Rate on Droplet Size at 275 kPa

Nozzle type	Droplet size (VMD) µm		
	0.8 L/min	1.9 L/min	3 L/min
Std. TeeJet 80°	390	470	560
XR TeeJet 80°	360	460	560
FloodJet	370	450	540
FullJet	–	680	770
Cone Jet	220	360	–

Methods of Controlling Drift

Timing the spray application

The most obvious way to reduce droplet drift is to spray when winds are less than 15 kilometres per hour. Pesticide applications in wind that is greater than 20 kilometres per hour should be avoided. Winds are generally lightest in the morning and near sunset, and spraying at these times is usually encouraged. Many pesticides perform the best when applied in the cool, humid conditions that are often present in the morning and near sunset.

Humidity and air temperature affect droplet drift by controlling the rate at which airborne droplets evaporate, become smaller and more drift prone. When using a water-based pesticide solution, spraying under humid conditions is better for drift control than spraying under dry conditions at the same temperature. The higher the temperature the faster the rate of evaporation and the greater the risk of drift.

Air temperature is also important because of its variation with height near the ground. During the night and until approximately an hour after sunrise, air near the ground is often cooler and more stable than the air above it; a temperature inversion exists. The situation where mist hangs over a lake or pond around sunrise is a good example of a temperature inversion. Spraying during a temperature inversion can produce a hazardous cloud of driftable droplets that remain concentrated near the ground. Avoid spraying during temperature inversions, especially near sensitive areas.

Using nozzles for drift control

The use of large orifice nozzles for pesticide applications is recommended for drift control. The greater the nozzle output the larger the droplets produced and the more resistance to drift. "Raindrop" and flooding-fan nozzles are examples of nozzles that use this approach, since they produce very few droplets small enough to drift. However, the smaller the droplet size is, the better the spray coverage will be. Large volumes of water are required for these types of nozzles to be effective. Large orifice nozzles should only be used when uniform surface coverage is not critical, such as when applying certain pesticides to soil.

One simple way of reducing droplet drift is to create a coarser spray by reducing the hydraulic pressure at the nozzle. However, this is seldom acceptable with ordinary flat-fan nozzles because the pattern is adversely affected by operating below the recommended pressure. A large reduction in pressure is required to significantly alter droplet size. Low pressure types of flat-fan nozzles that allow for low operating pressure while retaining a uniform pattern are available.

Nozzle spray pattern angle affects droplet drift by affecting droplet size and the boom height required for spray overlap. The smaller the nozzle angle is, the greater the mean droplet size is (VMD). For example, a 11002 nozzle operated at 275 kPa has a VMD of about 300 µm, while an 8002 nozzle at the same pressure has a VMD of about 400 µm, and a 6502 has a VMD of approximately 475 µm. However, the smaller the

nozzle angle is, the greater is the boom height that is required to obtain proper spray overlap. The higher the boom height is, the more vulnerable the spray pattern is to drift from wind. Thus, 65° nozzles produce larger droplets that are more resistant to drift but that require a higher boom, which makes the spray more prone to drift.

Spraying speed

Spraying speed has a bearing on spray drift, especially on rough terrain. Boom bounce caused by excessive speed can increase drift and result in poor spray distribution. This can lead to stripping problems, leaving areas of crop damage and poor pest control. The wind system responsible for spray drift is a combination of the wind and the air movement created by the moving sprayer, a feature that is most obvious for fast spraying-vehicles. Thus, excessive spraying speeds should be avoided.

Spray additives

Additives that coarsen the spray and reduce drift have been introduced onto the market. Foaming agents reduce drift but affect the spray deposit pattern. Surfactants may be added to improve the sticking and spreading of droplets on foliage. Claims have been made that surfactants reduce the evaporation rate from airborne droplets, thus reducing drift. However, tests have not yet established that this reduction does occur. The use of oils rather than water as the carrier solvent would similarly help in controlling drift, but their expense prohibits their widespread use.

Some drift control techniques include the use of additives that change the chemical solution to a foam-like substance when added to the spray tank. These products are designed for industrial applications and are NOT recommended for crop spraying.

Covered booms

Some sprayers are now equipped with shields that protect the spray pattern from wind. The shields either cover the whole boom (figure 6) or are restricted to cones that cover individual nozzles (figure 7). The obvious advantage of shields is that they reduced spray drift, especially under windy conditions, thus extending the time available for spraying. Recent studies using 8001 nozzles have shown that shields do not completely eliminate drift, even at low wind speeds, but help to reduce spray drift compared to unshielded sprayers by about 50 per cent. These same studies indicated that the deposit pattern of shielded sprayers has about 50 per cent more variation than unshielded sprayers.

Figure 6. Boom shield

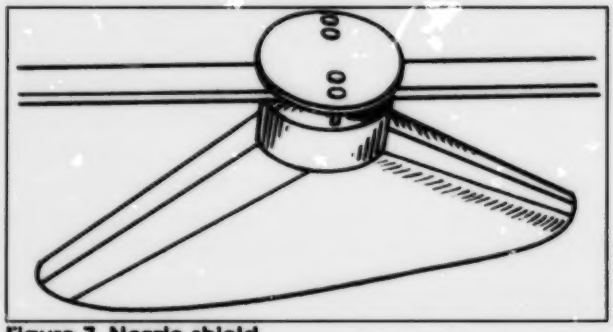

Figure 7. Nozzle shield

Sprayer Types

More pesticides are applied with sprayers than with any other type of equipment. There are many types and sizes of sprayers. Sprayers can be as small as an aerosol can or as large as a railway tank car. Application volumes vary from a few litres per acre to several hundred litres per acre.

The major part of this publication deals with the low-pressure, broadcast boom sprayer, the most common sprayer used in Alberta. This sprayer generally has nozzles tips mounted on a wet-boom at 50 centimetre spacings and applies an even swath of pesticide across the width of the boom. Tapered-edge, flat fan nozzle tips are used almost exclusively on this sprayer and provide a uniform spray pattern when operated at the optimum pressure and height settings.

Sprayers that are used for row crop application have the nozzles mounted on rubber hoses or drop-pipes which are clamped onto a dry-boom. The nozzles can slide along the boom frame to adjust for various row spacings. Row crop sprayers are generally equipped with even-spray fan nozzles which apply even bands of chemical without overlapping from one nozzle to the next as is the case with the tapered-edge flat fan nozzle. For special applications of insecticides or fungicides cone-type nozzles are also used with row crop sprayers.

Boomless sprayers are generally only used for spraying herbicides in pastures, on roadsides and other areas where rough terrain prevents access to a boom sprayer. Boomless sprayers, however, are also used to apply insecticides in field perimeters and grasslands. Their use in cropland is not recommended owing to inaccurate spray patterns and the drift potential created by the offset nozzles used on boomless sprayers.

Small sprayers, either hand operated or vehicle mounted, are useful for spot treatment in fields, spraying lawn areas and spraying in areas that cannot be entered by large equipment. These sprayers can be used for applying herbicides, insecticides or fungicides.

Mist blowers are almost exclusively used for applying insecticides and fungicides in orchard and vegetable crops. Foggers of various sizes are used for mosquito and fly control both indoors and outdoors.

The sprayers described above are available in numerous models and types and may be mounted on trailers, tractors, trucks, recreational vehicles or may be self-propelled.

Hand-held Sprayers

Nearly all hand-held sprayers are of the manually-operated compression type (figure 8). There are different sizes, shapes and materials, but the principle is the same. An internal or external compression pump is an integral part of the sprayer. Spray can be discharged onto the target for a short period of time before the pressure drops to where the operator must stop and pump it up again. Most compression sprayers come equipped with an adjustable nozzle that

Figure 8. Hand-held sprayer

delivers a cone shaped spray pattern and adjusts from a fine spray to a coarse spray and then to a stream that may reach three to five metres.

Backpack Sprayers

A typical backpack sprayer can be described as having a tank capacity of eight to twenty litres that is carried on the operator's back (figure 9). Continuous hand pumping is required to keep the sprayer operating. Backpack sprayers are not pre-pressurized as in the pump-up sprayer. The pumping action forces the liquid spray mixture out through a small surge chamber. Some of the pressure is retained in the surge chamber, but spray delivery slows down quickly when pumping stops.

By using a backpack sprayer an operator can handle larger quantities of spray liquid with greater comfort and freedom of movement than with hand-held compressed air sprayers. Backpack sprayers are adapted for larger jobs.

Figure 9. Backpack sprayer

On some models the pump handle can easily be switched from one side of the sprayer to the other. When large areas are being sprayed this minor difference can be a major advantage.

Stainless steel, galvanized steel and brass have been the predominant materials used for sprayer construction. Plastic units have gained popularity more recently due to their corrosion resistance and light weight. Being able to see the liquid level through the plastic sprayer tank is an additional convenience.

Some pesticides, particularly wettable powders, settle out rapidly when added to water. This can pose a problem with hand operated sprayers that have no mechanical or hydraulic agitation system. Therefore, hand-held or backpack sprayers must be shaken periodically during use to prevent the chemical from settling in the tank. Some newer models provide agitation by means of a bypass.

When spraying, the normal pumping and walking action will cause a certain amount of liquid movement in the sprayer. This can be a problem when only a small amount of spray solution is left in the tank. There is still enough liquid to continue spraying but air is introduced into the line. When air is pumped into the line, there is a sputtering of the spray that results in uneven application. This is a signal to refill the sprayer. (See calibration section for calibrating information).

Push Sprayers

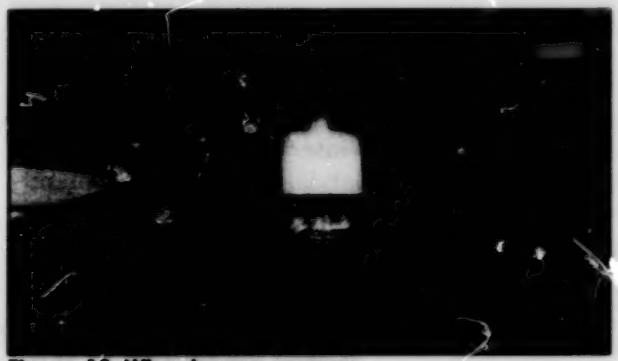

Figure 10. Wheelpump sprayer

One model of push-type sprayers operates at minimal pressure. The pressure is produced by a hose pump (figure 10). The pump is a flexible piece of surgical tubing stretched over a roller reel. The reel is attached to the ground wheel of the sprayer. As each roller revolves it squeezes the tubing creating a vacuum which then fills with the spray solution from the tank. The following roller then squeezes the solution further along the tubing. An adjustment for setting nozzle height is available on this type of sprayer.

All Terrain Vehicle (ATV) Sprayers

These sprayers are equipped with a 12-volt electric pump connected to a tractor battery or the ATV battery (figure 11). The pump requires only 5 amps to operate and delivers about 4.5 litres per minute at 200 kPa pressure. The sprayer can be equipped with a short boom and a handgun for spraying weeds or for spraying trees for insect control.

Figure 11. ATV sprayer

Caution: Because there is no agitation system in many of these sprayers, do not use wettable powder formulations of pesticides unless agitation can be provided.

Tractor-mounted Sprayers

Tanks on tractor-mounted sprayers usually hold from 100 to 2000 litres and can be mounted in several positions on the tractor (figure 12). The pump can be attached directly to the PTO shaft or may be driven by a hydraulic motor. Booms may be mounted in the front, rear, or belly positions. Broadcast applications may also be made with a nozzle cluster. This boomless-type of application may be used in pasture spraying. Tractor-mounted units are combined with other equipment such as planters, cultivators or tillage implements. The tractor-mounted concept is occasionally used for mounting sprayers on swathers, however, large tanks are not used because as the frames are unable to support heavy weights.

Figure 12. Side mount tank

Small three-point-hitch sprayers are commonly used by acreage owners and industrial institutions with large lawn areas (figure 13). Farmers also find these sprayers useful for spot spraying weed patches in the field.

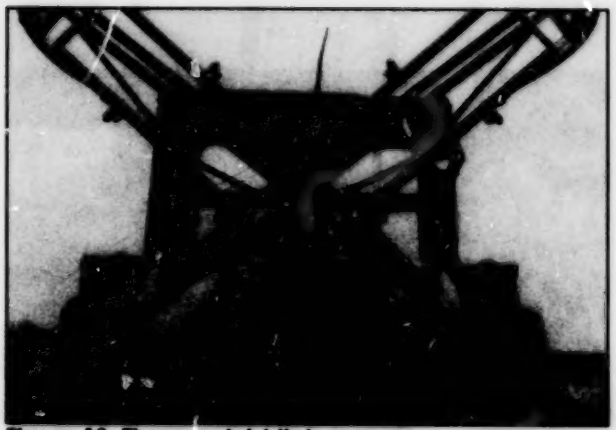

Figure 13. Three-point-hitch sprayer

Trailer-mounted Sprayers

Trailer-mounted sprayers the most common type of sprayers used by farmers in Western Canada, which are designed to be towed through the field by a tractor (figure 14). Tank capacity can be as large as 4000 litres with boom lengths up to 24 metres or more. Pumps are mounted on the tractor or sprayer and driven by the tractor PTO or a hydraulic motor. These sprayers are used to apply most pesticides in cereal and oilseed crops as overall broadcast sprayers. In most cases the nozzles are permanently set at 50 centimetre spacing in a wet boom.

A variety of small trailer-mounted sprayers are commonly used by acreage owners, industrial institutions and by farmers with large lawn areas (figure 15). These sprayers come equipped with either a 12-volt electric pump or a PTO pump. Handguns can be adapted to allow spraying of trees for insect control.

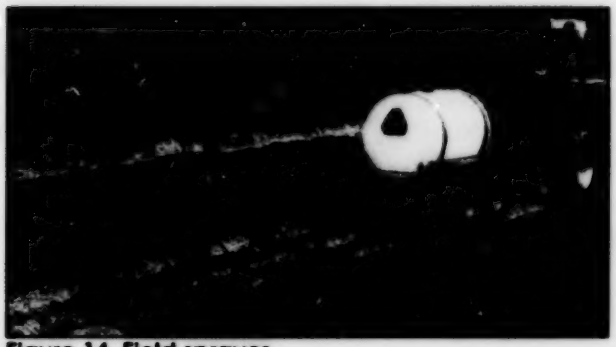

Figure 14. Field sprayer

Figure 15. Estate sprayer

Truck-mounted Sprayers

Sprayers on skids may be mounted on a pick-up or flat-bed truck. Pump power is supplied by an auxiliary engine. Tank size depends on the size of the truck used to carry the sprayer. Detachable booms are available for use in crop spraying (figure 16). These booms can be detached and the sprayer can be used for pasture spraying, roadside spraying or for any number of industrial situations, where it is too rough to use the field-size booms.

Some models of truck-mounted sprayers have a built-in boom that folds up for transport (figure 17). Boomless-nozzle systems can be used to spray areas with extremely rough terrain or areas with too many obstacles to use booms.

Larger sized sprayers mounted on large trucks are generally used for roadside spraying for brush and weed control or for spraying other rights of way such as pipelines and power lines

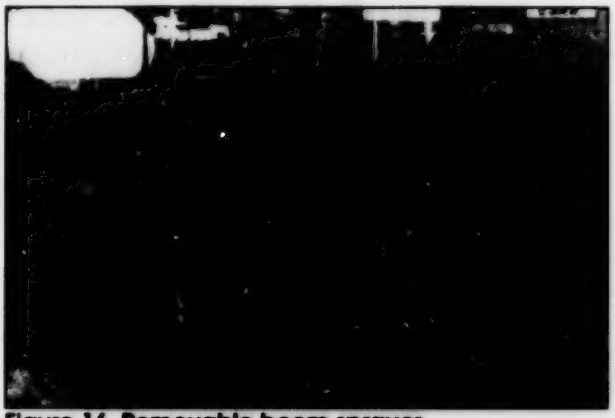

Figure 16. Removable boom sprayer

Figure 17. Folding boom sprayer

Figure 18. Roadside sprayer

(figure 18). These sprayers are generally equipped with a piston or diaphragm pump that can develop substantially higher pressures for use with a handgun. However, excessive pressure increases drift potential and is not generally recommended for applying herbicides.

Self-propelled Sprayers

Large self-propelled sprayers have floatation tires (figure 19). These tires cause less severe crop damage than normal width tires and allow operation under wetter soil conditions. Due to their initial cost "floaters" are best suited for large farmers or custom operations. Some units have a tank capacity up to 10,000 litres. Dust created by the large tires has resulted in poor weed control with some post-emergent herbicides; therefore, excessive speeds should be avoided for these operations.

Figure 19. Floater

Smaller self-propelled sprayers have been used for a number of years by Alberta farmers with varying degrees of success (figure 20). The potential for drift has been lessened by having height adjustments for the boom installed in newer models. These sprayers have a high clearance and an adjustable wheel width, to allow spraying of insecticides and fungicides in later crop stages as well as making them useful for row crop spraying.

Row crop sprayers have evolved from tractor-mounted sprayers (figure 21). The tank is underslung and fits between crop rows. The spray boom is raised or lowered depending on crop height and application requirements. An adjustable rear axle allows spraying in a wide variety of row spacings and wheel shields help prevent wheels from damaging low hanging crops.

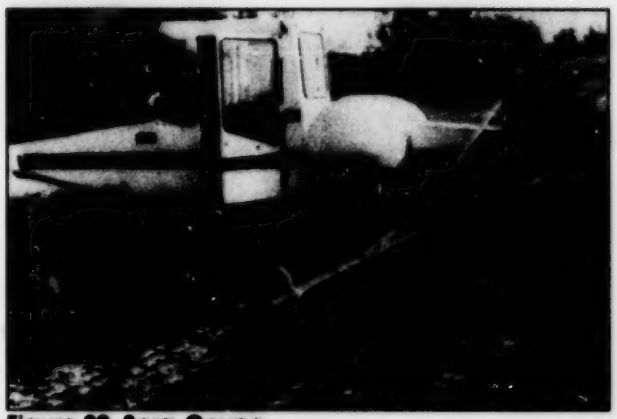

Figure 20. Spra-Coupe

Figure 21. Row crop sprayer

Mist Blowers and Foggers

Initially, the most common method of spraying fruit trees was with the use of a high pressure sprayer unit and one or more handguns. The continual increase in chemical costs along with the market's demand for improved quality of orchard produce created a need for cost-effective chemical application. Since that time, the use of a mist blower sprayer has been extended to many other types of crops. Today you find mist blowers in crops such as grapes, raspberries, blueberries, hops, evergreen trees and various types of vegetable farms (figures 22, 23).

Figure 22. Mistblower for tree spraying

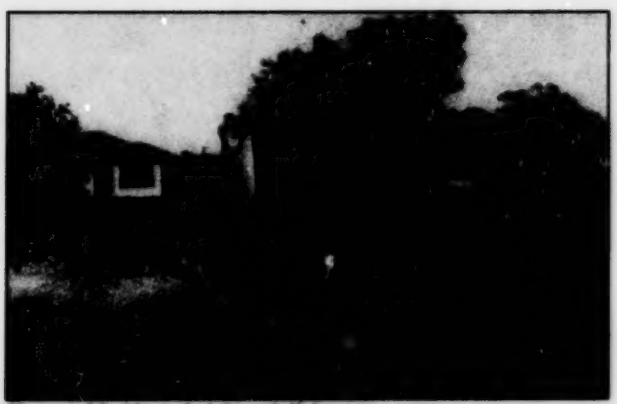

Figure 23. Vegetable mistblower

A mist blower uses air as a carrier for the spraying of liquid. Combining air and water as a carrier for the chemicals allows for a higher concentration of spray material, which means more acreage will be covered per tank.

Generally, hollow cone nozzles are commonly used on mist blowers. The size of nozzle will provide the correct volume and the type of swirl plate will create the droplet size in conjunction with pressure.

To get 100 per cent coverage, you must replace all the air in the leaf canopy with spray loaded air. The same principle applies to the spraying of trees, bushes or vegetables. Another factor to consider is the density of the crop you are spraying. This, together with the weight of the leaves and thickness of the stem, will determine the speed and volume of air necessary for good penetration. It can change between two different varieties of the same crop and with their stage of development.

Another fact to consider, especially when spraying grapes, berry bushes and vegetables, is the bouncing effect the air can have on a dense leaf mass. Since all crops try to expose the leaf surface to the sun, it can sometimes be hard to get thorough penetration. Some sprayers are equipped with adjustable outlet spouts. The best results are reached by adjusting these spouts 30° to 45° backwards from the direction of travel. One important factor for good penetration is the forward speed of the equipment. A rule of thumb is never drive faster than seven kilometres per hour when spraying with a mist blower.

Figure 24. Motorized backpack mistblower

Figure 25. Portable fogger

Motorized backpack sprayers can be used for liquid spraying, fogging or for applying dusts and granules (figures 24, 25).

Aircraft Sprayers

The principal advantages of aircraft sprayers (figure 26) compared to ground equipment are:

- application can be made in places and at times when ground equipment cannot operate
- speed of application will save time
- elimination of soil compaction and crop damage
- no capital investment required by the farmer.

Among the disadvantages to be considered are:

Figure 26. Aircraft sprayer

- drift hazard is greater
- not applicable to small fields
- unless properly calibrated and operated, aircraft sprayers are not as thorough in applying herbicides as ground rigs.

Helicopters are more manoeuvrable than fixed-wing aircraft and are not restricted to operating from a landing strip. However, they are more costly to use than fixed-wing units and have a smaller payload.

Pesticides are applied in either a water or oil carrier, depending upon the chemical make-up of the herbicide. The label must be consulted for recommendations on rate, addition of an adjuvant, water volume and whether or not the product is registered for aerial application.

Wiper Applicators

A weed control technique being researched and tried on a limited scale is the use of height-selective applicators. This weed control equipment relies on a height difference between the crop and the weed to achieve selective control. Generally, the weeds must be at least 15 centimetres above the crop. Several types of applicators are available. These applicators may have a use in row crop situations and other areas where tall-growing weeds affect crop production.

Roller Applicator

This unit has a rotating roller that is carried above the crop (figure 27). A herbicide is applied

Figure 27. Roller applicator

to the roller and is wiped onto the weed growth above the crop.

Rope-wick Applicator

Rope-wick applicators operate similarly to a roller applicator (figure 28). The roller is replaced by a pipe containing herbicide and is fitted with pieces of rope that are wetted with herbicide through capillary action. The rope wipes the herbicide onto the weeds growing above the crop. Rope-wick applicators can be homemade or purchased commercially.

Figure 28. Ropewick applicator

Hand-held Wipers

Hand-held wipers are generally constructed of a plastic pipe shaped like a hockey stick with a rope or ropes mounted on the blade portion (figure 29). The rope is connected into the pipe to allow chemical solution in the pipe to wick through the rope to be wiped onto the vegetation.

Figure 29. Hand-held wiper

This type of weed wiper was designed for the home and garden situation to treat smaller areas and remove unwanted growth near desirable vegetation. The herbicide will control only those emerged plants that are directly contacted by adequate amounts of solution. Repeat treatments will be necessary to control vegetation that was not contacted or did not receive sufficient contact during the initial treatment.

All of these systems have advantages and disadvantages.

Advantages:

- Selectivity can still be achieved with a non-selective herbicide.
- Smaller quantities of herbicides are applied on a per acre basis, reducing chemical use, cost and soil residues.

Disadvantages:

- The level of control is lower than with conventional spraying.
- Low growing weeds are not controlled.
- Some weeds are not controlled even if adequately contacted.
- Weeds are controlled later in the season, after considerable competition has taken place.
- New equipment is required.
- Travel over advanced crop may cause trampling.
- Whipping effect of contacted weeds may splash non-target plants.

Height-selective applicators will likely develop as a supplement to current weed control methods and will be used primarily to clean up weeds that have escaped control and to control patch infestations of perennial weeds. Row crops that allow later season traffic without trampling the crop and control of weeds in forage crops may be other areas where height selective applicators will be useful.

Sprayer Components

Sprayers and other application equipment have three basic functions to perform:

- Storing chemicals during field application
- Metering the quantity of material being applied
- Distributing the material accurately in the desired pattern.

To perform these functions, sprayers have numerous components which can be arranged in many ways. For a particular situation, the best combination depends on:

- the chemical being applied
- the crop being treated
- the application rate
- the required accuracy.

Sprayer Tanks

Sprayer tanks are available in a variety of shapes, sizes and materials. Square tanks and tanks with flat bottoms should be avoided because proper agitation and cleaning are difficult. The most popular shapes are the oval tank and the cylindrical tank. They both have good agitation and cleaning characteristics.

Tank sizes should be proportional to sprayer boom width and intended application volumes. Sprayers with a boom 15 metres wide or wider should have a minimum tank size of 1400 litres. With an application rate of 40 litres per acre travelling at a speed of eight kilometres per hour and a boom width of 15 metres, a 1400 litre tank would cover 35 acres in just over one hour. A smaller tank would require more frequent refilling, reducing field efficiency. Larger tanks reduce the number of refilling stops, but require that special attention be paid to the undercarriage to prevent excessive crop damage.

The tank must have a conveniently located, large opening for filling, cleaning and inspecting. An opening of 30 to 45 centimetres is usually sufficient. The opening should be splash-proof and fitted with a large 80 or 100 mesh screen. The lid should be vented and leak proof. This will help to keep the outside of the tank clean and free from corrosion and pesticide which can contaminate the operator. The drain hole must be located in the tank bottom to allow complete draining. A liquid level gauge complete with capacity markings is a must.

Tanks are available in galvanized steel, stainless steel, aluminum, fibreglass and polyethylene. Mild steel is not recommended as it corrodes readily, requiring considerable maintenance. The above mentioned materials are resistant to most chemical corrosion; however, the operator must check the chemical label for instructions and precautions.

Galvanized Steel Tanks

These tanks are inexpensive and are made in a variety of shapes and sizes. They are easily repaired or modified. The biggest drawback is corrosion. Even with protective coatings, chemicals cause rapid rusting. Rust flakes off, plugs nozzles, clogs strainers and damages pumps. Galvanized tanks are suitable for most pesticides, but they should not be used with the more corrosive liquid fertilizers and are not recommended for some herbicides.

Stainless Steel Tanks

Stainless steel is the highest quality material for pesticide applicator tanks. It is strong and resistant to corrosion by crop chemicals. Because it is the most expensive material used for sprayer tanks, only equipment with high levels of yearly use is equipped with it.

Aluminum Tanks

Aluminum tanks are moderately expensive. They resist corrosion and are suitable for many chemicals. However, they should not be used for liquid nitrogen solutions. Lab tests have shown that the herbicide TCA has some chemical reaction with aluminum; however, no problems should arise if the tank is cleaned immediately after use.

Fibreglass Tanks

Fibreglass tanks are widely used on all types of sprayers and as nurse tanks. Fibreglass is strong and durable. However, it will crack or break under sharp impact. "On farm" repair kits are available for minor problems. The cost of fibreglass is about equal to that of aluminum. Some types of solvents may affect fibreglass tanks.

Polyethylene Tanks

Polyethylene tanks are relatively inexpensive and can be made in many sizes and shapes. They are resistant to corrosion and can be used with all pesticides and with most fertilizers except ammonium phosphate solutions. Polyethylene tanks are tough and durable; however, if one is cracked or broken it must be replaced because there is no effective way to repair it. Because polyethylene breaks down under ultra-violet light, tanks should be stored inside when not in use.

Undercarriage

The undercarriage of a sprayer not only carries the weight of the tank and contents, but also provides the main support for the booms. Polyethylene and fibreglass tanks must be properly mounted on a "saddle" that supports the tank over a large area. Without it, the weight of the liquid in the tank may damage the tank as the sprayer bounces over rough terrain.

Sprayers with large tanks should have enough wheels to provide a level of floatation that will prevent crop damage. The tandem axle or walking beam axle arrangement is preferred (figure 30). With the wheels following in the same track, compaction and crop damage may be kept to a minimum. The walking beam axle provides a

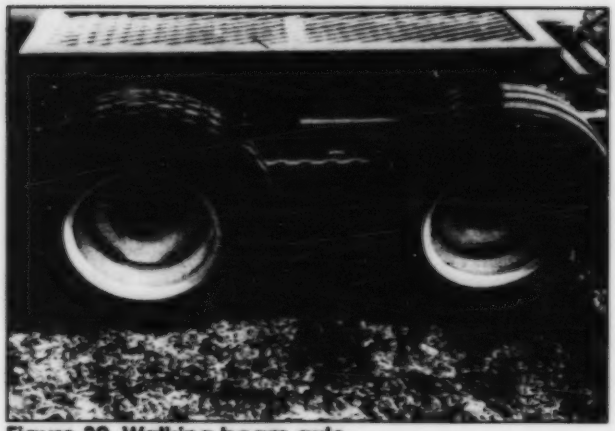

Figure 30. Walking beam axle

smooth steady support for the booms, maintaining a more even height above the target.

On many of the larger sprayers, both the booms and the trailers are equipped with either floatation tires or tandem wheels. Prairie Agricultural Machinery Institute (PAMI) tests have indicated these are effective in reducing compaction and boom movement, but many farmers are concerned about crop losses from trampling. Trampling from spraying amounts to less than two per cent, and usually much of the crop recovers. About half of the trampling is caused by the tractor; the only additional loss is from the boom wheels. Thus, sprayers (regardless of design) cause little loss beyond that caused by the tractor itself.

Mounted or self-propelled sprayers require an undercarriage that keeps boom height even and reduces boom oscilliations (figure 31). Sprayer width is limited because outrigger wheels are not used.

Figure 31. Self-stabilizing boom

Sprayer Pumps

Pump Requirements

A variety of pumps can be used on sprayers. Each kind has certain capabilities and limitations that determine when it should be used. The roller and centrifugal pumps are the most common types employed on agricultural sprayers.

The roller pump affords relatively low cost, easy upkeep and efficient operation at tractor PTO speeds. However, roller pumps tend to wear from continuous use and need replacement. Abrasive material will cause extensive wear in roller pumps. The advantage of other pumps is that abrasives can be used with them.

Pumping requirements on a farm sprayer are modest. Pressure is relatively low and volumes required are usually under 100 litres per minute. Nevertheless, adequate pump capacity is a must for proper sprayer functioning. Pump capacity is determined by the following factors: rate of application per acre, width of the sprayer, speed of travel, and size of tank (agitation requirement).

Table 4 gives the pumping capacity required for various sprayer sizes. Consideration was given for agitation requirements and an allowance added for normal wear. When selecting a pump be sure that its capacity is rated at the pressure you will be operating at. Some manufacturers rate their pumps at zero back pressure and of course this capacity is greater than at 275 kPa.

Table 4. Pump Size Requirements to Apply 40 L/acre

Boom width m	Sprayer tank size L	Pump capacity L/min
10	680	34
10	900	38
10	900	42
12	1130	46
12	1350	50
12	1130	53
15	1350	57
15	1800	65
15	1350	63
18	1800	72
18	2270	80
24	1850	85
24	2270	93

Pump Capacity Check

A worn pump is indicated if spraying pressure can not be achieved with boom valves open and pump operating at the correct rpm. This could also be an indication that nozzle tips are worn.

To check pump capacity the following procedure can be used.

a. Shut off boom and agitator lines.

b. Release pressure on relief valve.

c. Direct total pump output through the bypass line at the required rpm into a container for one minute.

d. Measure the liquid collected.

e. The measured amount of liquid equals pump output/minute.

Roller Pumps

Roller pumps are commonly used because of their low cost and compact size. They operate at 540 and 1,000 rpm. They are easily repaired and have adequate capacity for field sprayers. Roller pumps can be used to pump plain water and other pesticide solutions including wettable powders. The roller material should be compatible with the solution being pumped. Always check manufacturer's information on pump use.

The rollers of a roller pump fit into slots of a rotating hub. The slots allow the rollers to follow the eccentric shape of the housing. As the rollers pass the inlet port, the space between rollers and the housing becomes larger and draws fluid into the pump. The fluid remains between two rollers

Figure 32. Roller pump

Table 5. Pump Capacities

Roller pumps		
Delavan	7-0000	50 L/min @ 540 rpm
	7-4110	57 L/min @ 1000 rpm
Hypro	Series 1200	189 L/min @ 540 rpm
	Series 1500	95 L/min @ 540 rpm
	Series 1700	68 L/min @ 540 rpm
	Series 1700	136 L/min @ 1000 rpm
	Series 7560	42 L/min @ 540 rpm
	Series 7560	83 L/min @ 1000 rpm
	Series 7700	45 L/min @ 540 rpm
	Series 6500	45 L/min @ 1000 rpm
Centrifugal pumps		
Ace	PTOC	190 L/min @ 1000 rpm
	PTOCH	230 L/min @ 1000 rpm
Delavan	Turbo-90	100 L/min @ 1000 rpm
Hypro	Series 9000	329 L/min @ 540 rpm
Diaphragm pumps		
Imovilli	D105C	103 L/min @ 540 rpm
	MV40C	38 L/min @ 540 rpm
Hypro	Series 60	50 L/min @ 540 rpm
	Series 100	103 L/min @ 540 rpm
	Series 150	145 L/min @ 540 rpm
Comet	BP 105/20	113 L/min @ 550 rpm
	BP 210/20	248 L/min @ 550 rpm
Hardi	Model 500	20 L/min @ 540 rpm
	Model 600	40 L/min @ 540 rpm
	Model 120	083 L/min @ 540 rpm
	Model 130	1114 L/min @ 540 rpm
	Model 320	50 L/min @ 540 rpm
	Model 460	234 L/min @ 540 rpm
Piston pumps		
Hypro	Series 5400	88 L/min @ 540 rpm
Bean	6-30	117 L/min @ 540 rpm
Bean	6-60	234 L/min @ 540 rpm

as it moves to the outlet port. As the rollers near the outlet port, the spaces become smaller and the fluid is expelled from the pump.

Preparation

- Rotate shaft by hand to ensure the pump has not seized.
- Ensure the pump is securely coupled.
- Suction lines must be secure and free of air leaks. Sucking air into the system reduces efficiency and can cause chemical to foam.
- With at least one boom section open, run the pump for one or two minutes at zero pressure to evacuate all air.
- Never exceed the recommended rpm.
- Ensure plumbing is of adequate bore size, especially on the inlet side. Also check that there are no restrictions in the line.

Maintenance

- Always flush the pump thoroughly with lubricating oil after use.
- Test the pump at the end of each season by running it at 275 kPa pressure and checking that the flow is sufficient for maximum sprayer application required.
- Examine condition of rollers. If reduced in size, or worn to a 'conical' configuration, the pump should be reconditioned or replaced.
- To recondition the pump, replace all rollers and seals. Take great care in correctly locating seals on reassembly. If the shaft is badly worn, it should be replaced. This can be difficult, and purchase of a new pump should be considered. If the inside of the pump body is worn or corroded, a new pump should be purchased. Normally a roller pump can be satisfactorily reconditioned only once.

Table 6.Troubleshooting Roller Pumps

Problems	Remedy
Pump does not suck.	Replace rollers and seals or replace pump.
Air enters inlet side of pump.	Check inlet coupling and plumbing for Leaks. Rotate pump with outlet taps open.
Pump becomes noisy.	Check inlet plumbing for restrictions or blockage.
Inside of pump body is worn or corroded.	Replace pump.
Pressure and output drop.	Replace, roller, seal, or pump.
Nozzles spits.	Check inlet/suction hose and couplings for air leaks. Ensure all washers and seals are correctly positioned.

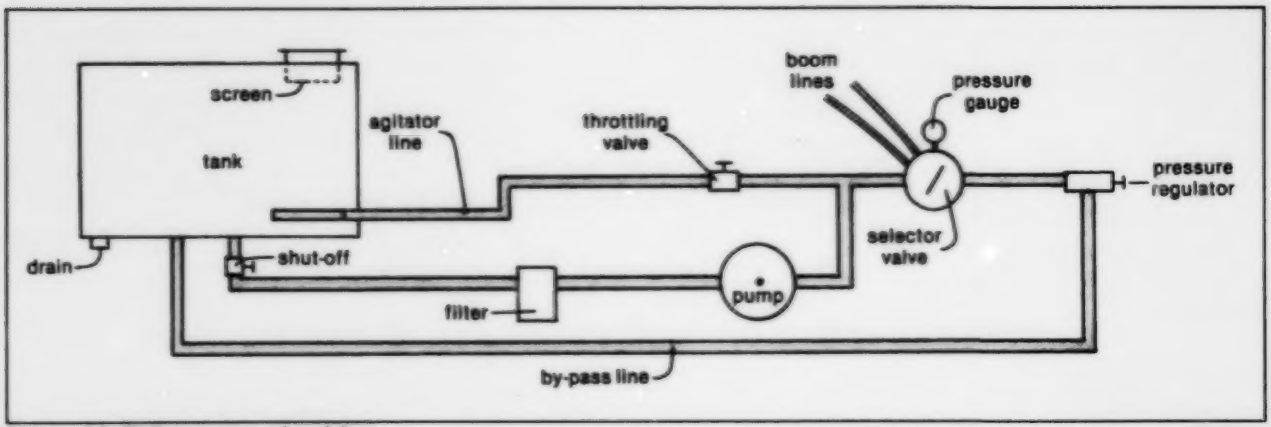

Figure 33. Roller pump plumbing

Centrifugal pumps

Centrifugal pumps have become increasingly popular because they handle abrasive materials well and have a high capacity to provide adequate hydraulic agitation (figure 34). Centrifugal pumps must be driven at a high speed to develop pressure. Pump output falls off rapidly above 300 kPa pressure. The main disadvantage of centrifugal pumps is that the output decreases rapidly with small reductions in pump speed. Turbine pumps have similar characteristics to the centrifugal pumps but run at a lower rpm.

Maintenance

- When the unit is not to be used for an extended period of time, follow these instructions:
- Plug the hydraulic motor ports to retain some hydraulic oil in the motor and prevent internal rusting.
- Remove the bottom vent plug in the pump and drain the fluid. Flush some light oil in the pump to cover internal parts and prevent rusting.
- Always rotate impeller by hand to be sure the unit is free before reusing it.

Centrifugal pump plumbing

- A small plastic vent tube leads from the top drain opening in the pump housing back to the tank. This positive vent line allows the pump to prime itself by bleeding-off trapped air when the pump is not operating. The small stream of liquid that flows back to the tank when the pump is operating is negligible.

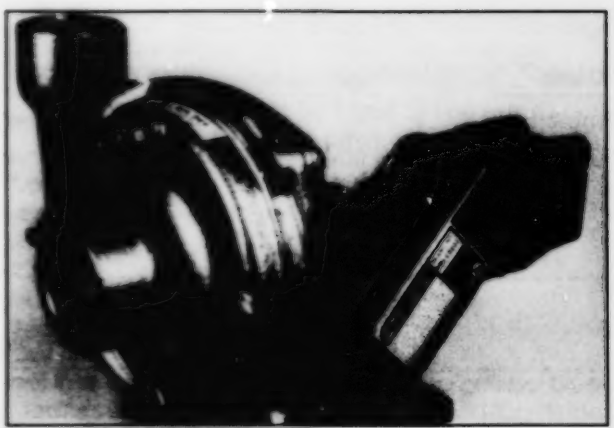

Figure 34. Centrifugal pump

- No relief valve is used.
- Because the primary purpose of the line strainer is to prevent clogging of the spray nozzles, it is shown in the line to the boom or spray gun. A small strainer is adequate in this position because much of the pump output is recirculated. Alternate locations are in the suction line, if its capacity is adequate for the pump, or at the pump outlet.
- Two flow control valves are used, one in the agitation line and one in the line leading to the boom or spray gun. This permits control of agitation flow independently of nozzle flow.

Diaphragm Pumps

The pumping action in a diaphragm pump is produced by the movement of a flexible diaphragm (figure 36). Liquid is drawn into one chamber on the downstroke and forced out of another one on the upstroke. The diaphragm is

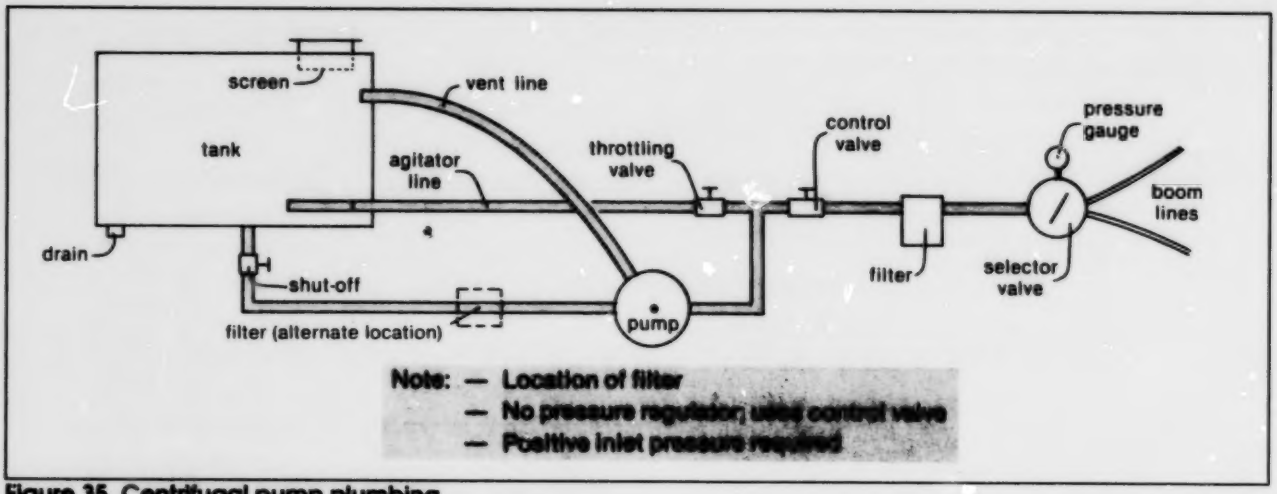

Figure 35. Centrifugal pump plumbing

Table 7. Troubleshooting Centrifugal Pumps

Problem	Causes and remedies
Pump doesn't deliver flow	a. Suction strainer clogged: clean strainer. b. Loss of prime: install sump or anti-vortex fitting in tank. - make sure discharge end of bypass or agitation line positioned below liquid level in tank - check suction plumbing for leaks. c. Collapsed suction hose: replace with wire-reinforced hose and increase hose size if undersized. d. Too much suction lift: reduce amount of suction lift.
Liquid leaking at juncture of centrifugal pump and hydraulic motor	a. Pump seal leaking: follow pump disassembly instruction and replace face seal. b. Motor seal leaking: follow pump and hydraulic motor disassembly instructions and replace seal.
Lack of pressure	a. Insufficient motor speed on "open-centre" hydraulic systems: adjust motor speed b. Excessive restriction on discharge side: increase discharge hose and fittings up to recommended size, check for clogged line strainer or pump capacity may be exceeded.
Inability to reduce pressure to desired level	a. Excessive motor speed on "open-centre" spraying range hydraulic systems: adjust motor speed b. Bypass or agitator plumbing too restrictive: increase size of hose and place pressure gauge as near to spray nozzles as practical.
Hydraulic fluid becomes too hot	a. Clogged oil filters or dirty oil: replace hydraulic oil and filters at recommended intervals. b. Improper system maintenance: keep hydraulic oil at proper level, clean dirt from system, keep relief valves adjusted properly and check for dented or kinked lines. c. Incorrect application of hydraulic motor: check tractor specifications.
Hydraulic motor operates in an erratic manner	a. System trouble: check system for air or fluid leaks. Check fluid for proper quantity and viscosity. b. Motor wear: inspect motor for excessive wear caused by impurities in system. Replace if necessary. c. Hydraulic hose quick-couplers not transferring oil from tractor hydraulic system: be sure coupler ends are clean and locked together in the operating position.

resistant to wear by abrasives but may be attacked by certain chemicals.

High volume, high pressure, diaphragm pumps are being used on industrial sprayers with success. Plumbing a diaphragm pump into a sprayer is the same as for a piston pump (see figure 37).

Preparation

- Ensure oil level is at least halfway up oil reservoir. (Hardi Pumps are grease lubricated, so oil is not used.)
- Suction lines must be secure and free of air leaks. Sucking air into the system seriously reduces efficiency and can cause chemical to foam.
- With at least one boom section open, run the pump for one or two minutes at zero pressure to evacuate all air.
- Never exceed recommended rpm.
- Ensure plumbing is of adequate size, especially the input side. Also check that there are no restrictions in the line.

Maintenance

- Clean the pump after use by running clean water through for a few minutes. Finish with the suction line out of the water to empty the pump.
- Check oil level and if necessary top up with a good 20W/30 oil. If the oil changes color, or disappears completely, refer to table 8.
- Change oil every 200 hours or at the end of the season, whichever comes first. To drain, remove the oil filter plug, normally located at base of the pump body. Rotate the shaft by hand until oil stops flowing. Slowly refill with oil, rotating the shaft by hand at the same time, until the level is halfway up the reservoir.
- Replace all diaphragms, valves and 'O' Ring seals at the end of each season.

Table 8. Troubleshooting Diaphragm Pumps

Problems and causes	Remedy
Pump does not suck. One or more valves are damaged or not seating properly.	Check valves and clean valve seats.
Suction filter is blocked, or there is a restriction on the suction side.	Clean filter and check for restrictions in suction line.
Pressure gauge fluctuates badly. Nozzles "spitting". Pump is not completely evacuated of air or is sucking air.	Check suction hose and couplings for air leaks. Rotate pump with outlet taps open until nozzles stop "spitting".
Pump pulsates and so does pressure gauge needle. Incorrect air pressure in air receiver	Starting at zero, progressively pressurize air receiver while pump is running until pulsations cease (normally between 25% and 33% of operating pressure).
Water pumped at little or no pressure.	Pressure regulator faulty. Pump has insufficient capacity for nozzles fitted. Check flow rates on nozzle chart times the number of nozzles.
Output drops and pump becomes noisy. Oil level is too low.	Top up with multigrade oil to correct level.
Oil changes color One or more leaking diaphragms are allowing chemical to mix with oil.	Check diaphragms and valves. Drain oil. Refill with oil.
Oil disappears and comes out of discharge pipe. One or more diaphragms are split.	Drain oil from pump. Dismantle heads and check diaphragms and valves (remember a broken valve can fall into the cylinder and split the diaphragm). Fit with new diaphragms. Refill with oil.
Oil level drops steadily and persistently. Shaft oil seal is leaking.	Strip pump and fit with new oil seal.

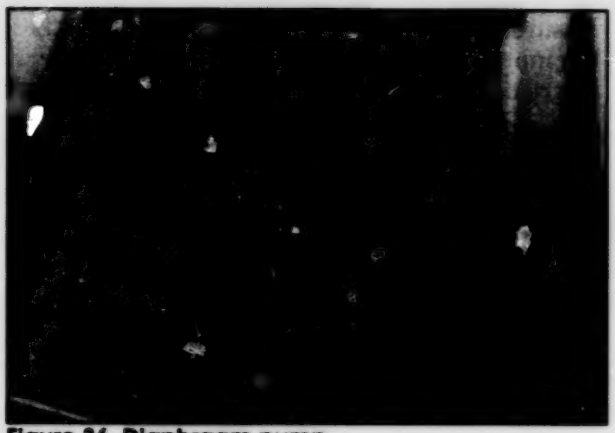

Figure 36. Diaphragm pump

- Completely drain pump for winter storage, especially the manifolds. Protect from frost.

Piston Pumps

Piston pumps are primarily designed for high-pressure spraying applications (figure 37). Piston pumps are positive displacement pumps, which means that output is proportional to speed and virtually independent of pressure. They are a good pump for wettable powder suspensions and other abrasive liquids. These pumps are suitable for use on field sprayers but are not commonly used owing to their high purchase price. However, they are one of the best types of pumps for custom operators or on any utility sprayers.

Piston pump hook-up

The connection for a piston pump is similar to that for a roller pump except a surge tank has been introduced at the pump outlet (figure 38). This accessory reduces the line pulsation that is characteristic of piston pumps.

Figure 37. Piston pump

In spraying applications where pressures well below 1400 kPa are adequate, the system may be connected with a standard relief valve (figure 42). When pressures over 1400 kPa are used, the relief valve should be replaced by an unloader valve (figure 43). This decreases the pressure on the pump and the load on the engine or motor when the spray gun or boom valve is closed.

Ground Driven Metering Pumps

Metering pumps are driven by a ground wheel (figure 39). When the speed changes, the rate of

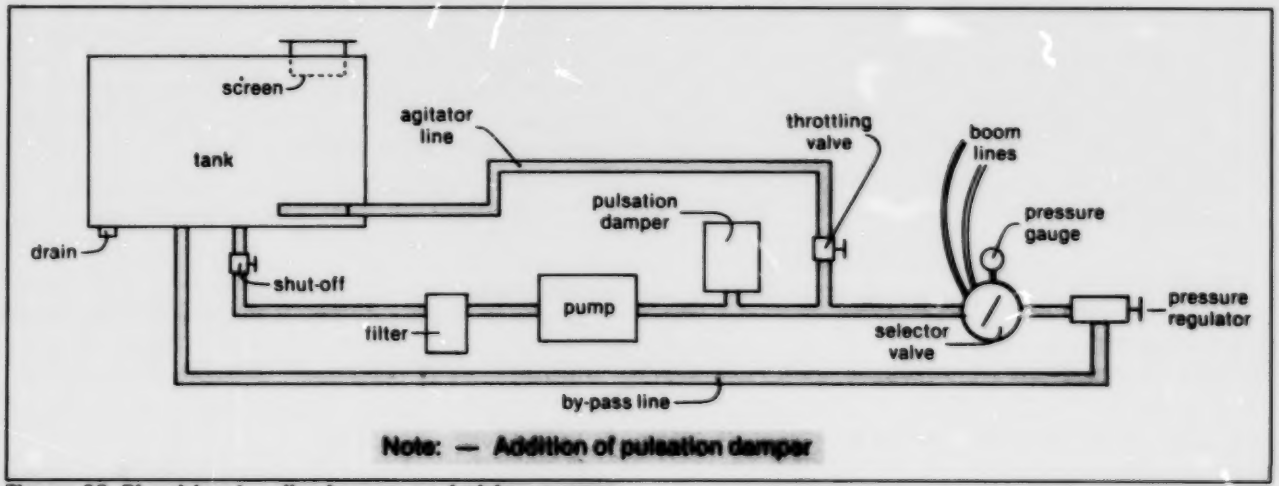

Figure 38. Plumbing for diaphragm and piston pumps

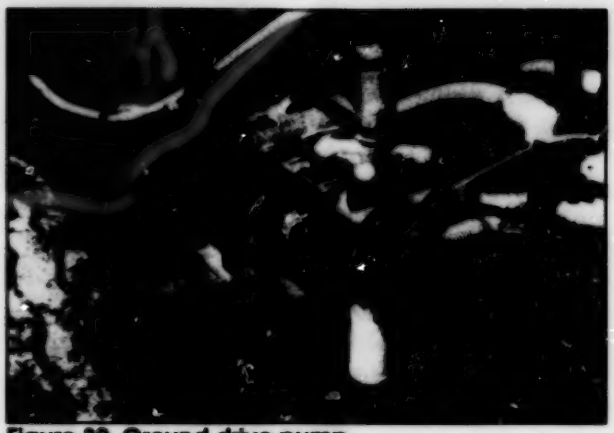

Figure 39. Ground drive pump

pumping increases or decreases proportionately. Thus, the application rate is held constant. Variable-stroke piston pumps are designed to change the length of the piston stroke to adjust the application rate. Increasing the piston stroke increases flow; reducing the stroke cuts the flow. Some pumps have a dial setting to indicate the output required. Other models require changing the sprocket size according to the desired volume. These pumps are mainly used in liquid fertilizer applicators; however, some manufacturers of herbicide sprayers offer these pumping systems.

Hoses

Hoses convey the liquid through the sprayer. Liquid pressure varies at different points in the sprayer. Hoses and pipes must be strong enough to prevent bursting. The rated working pressure of a hose decreases as the diameter increases. Be sure hoses are rated for higher capacity than the expected operating pressure, to provide a margin of safety and avoid bursting from pressure surges.

Suction hoses are not pressurized and will not burst, but they can collapse if the inlet becomes plugged. The diameter of a suction hose should be at least as large as the pump inlet port. The hose must be chosen carefully and should be a non-collapsing, wire-reinforced type. A collapsed suction hose can restrict the flow of liquid and "starve" a pump, causing decreased outflow and greatly accelerated wear. The inner and outer layers of all hoses should be resistant to the chemicals that will be used. Check with both the chemical supplier and the hose supplier if there is any doubt. A hose weakened by chemical attack can leak or burst unexpectedly.

Hose size is important because pressure losses affect flow rates. Pressure loss depends on hose diameter, length and flow rate (table 9). Although pressure losses may not seem significant in hoses shorter than two metres, it is wise to use a hose of the recommended size to minimize pressure and power losses.

Table 9. Pressure Loss in Rubber Hoses[1]

Hose inside diameter mm	Pressure loss at 20 L/min kPa	Pressure loss at 40 L/min kPa
7.5	70.0	240.0
15.0	3.5	6.9
22.5	0	3.5

[1] Pressure loss over 30 cm interval.

Sprayer Controls and Monitors

Valves

Valves are required at several points throughout the plumbing system of the sprayer. Depending on the application, gate valves or ball valves are recommended. Valves are required to control the agitation system and the hand gun. A ball valve is normally installed on the suction line upstream from the main filter. This enables cleaning of the filter while there is liquid in the tank. A valve on

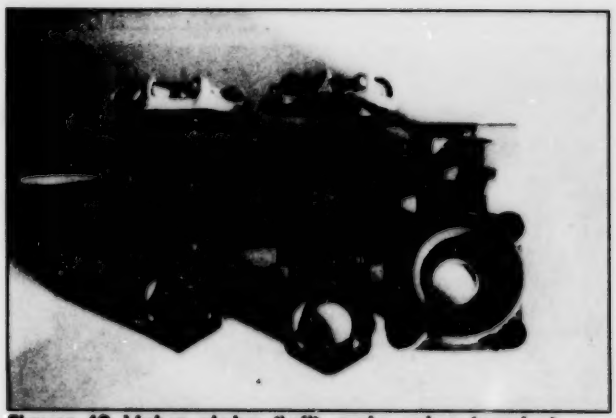

Figure 40. Valve globe (left), gate valve (centre) and ball valve (right)

the tank drain is very handy and can be installed to replace the drain plug. This makes cleaning the tank more convenient and reduces the chances of the operator coming in contact with the chemical mixture while draining the tank.

Gate valves or ball valves are preferred to globe valves (figure 40). Owing to the design of a globe valve, liquid passing through it must make two 90° turns thus restricting flow. Globe valves may be used in lines that require throttling such as the agitation line.

Pressure Controls

Pressure loss

In any system where flow of liquid is involved there are pressure drops between the pump outlet and the discharge point. The amount of pressure loss depends upon:

- size of hose
- length of hose
- flow rate
- other fittings in the lines (restrictions).

In field sprayers, the pressure gauge is usually located close to the pump outlet, and there can be a significant pressure loss by the time the liquid reaches the nozzle. With adequate lines and fittings and proper design, this loss can be kept at a minimum. Many older sprayers (particularly those which were originally designed to apply 20 litres of spray per acre) have severe pressure losses when operated with larger nozzles. Losses as high as 150 kPa can occur and cause severe distortion of the spray pattern, as well as a significant reduction in the application rate.

A pressure drop can also occur on the inlet or suction side of the pump. The allowable restriction at this point is critical, since the output and life of the pump can be affected. A total pressure drop of less than 30 kPa is desirable. This includes the total drop through fittings, filter and inlet hose. Since most filters, cause a pressure drop of 15 to 25 kPa (depending on the flow rate) when clean, it is necessary that the remainder of the suction line not cause a pressure drop of more than 15 kPa at maximum flow. Hose and fitting sizes must be correctly chosen. A large pressure drop will shorten the pump life and dramatically reduce output.

A pressure drop can be reduced by selecting the correct line sizes, reducing the length of hoses as much as possible and minimizing the number of fittings, elbows or sharp bends. Every attempt should be made to use the largest fittings that are available for the hose size (table 10).

It is important that the desired pressure be maintained at the nozzles (figure 41). Usually the pressure at the nozzles can only be determined by placing a pressure gauge in the boom itself.

Note: Use of ball check strainers at the nozzles requires a 35 kPa increase in pressure to maintain correct nozzle output.

Relief valve

A relief valve is a safety device that releases liquid when the pressure exceeds a safe level (figure 42). Relief valves can be used to regulate

Table 10. Plumbing Sizes (Inside diameter in millimetres)

Pump outlet	Boom line	Boom pipe	Bypass line	Agitator line	Filter ports
20	13	20	13	13	25
20	13	20	13	13	25
20	20	25	13	13	25
20	20	25	13	13	25
20	20	25	13	13	25
20	20	25	25	13	25
25	20	25	20	13	25
25	20	25	20	20	25
25	20	32	20	20	25
25	20	32	25	20	25
25	20	32	25	20	25
25	20	32	25	20	32
25	20	32	25	20	32

sprayer pressure by adjusting them to open at the desired pressure. When used this way, the valve is always partly open while the sprayer is operating. The excess flow is bypassed back to the tank.

Unloader valve

Spraying systems operated at pressures over 1400 kPa should use an unloader valve in place of a relief value to unload the pump when the distribution system is turned off (figure 43). An unloader valve opens and enables the pump output to flow back to the tank at low pressure. This reduces pump wear as well as relieving the pressure on the entire system.

Electric pressure regulators

This type of regulator provides remote pressure control in agricultural spraying applications (figure 44). Wetted metal parts are made of stainless steel with a nylon body and polypropylene cover for the gear motor. The valve operates on a 12-volt system at pressures up to 700 kPa.

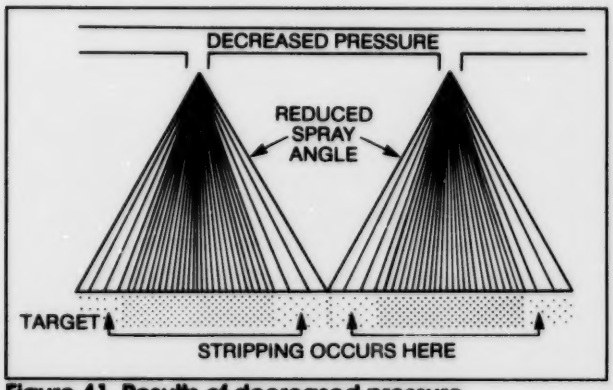

Figure 41. Results of decreased pressure

Figure 42. Pressure relief valve

Gauges

The importance of a pressure gauge is often overlooked. Its reading is an indication of the rate of application being applied (figure 45). A spare, accurate gauge should be kept on hand in case of failure and for checking boom pressure.

Pressure gauges should have a total range of twice the maximum reading expected. Gauges reading 0 to 450 kPa or 0 to 700 kPa are satisfactory. Gauges should be checked yearly for accuracy. If in doubt, replace the gauge because it is not an expensive item. The gauge should also be equipped with a pulsation damper (figure 46) to keep the needle from fluctuating. Several manufacturers have glycerin-filled or oil-filled gauges available. The liquid-filled gauges dampen any pump pulsations that can damage the gauge and make reading it difficult.

Ideally, sprayer pressure should be taken at the boom near the nozzle; however, many sprayers

Figure 43. Unloader valve

Figure 44. Electric pressure regulator

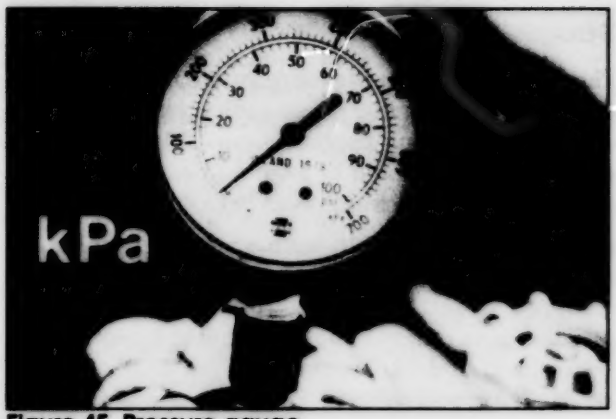

Figure 45. Pressure gauge

Figure 46. Gauge dampener

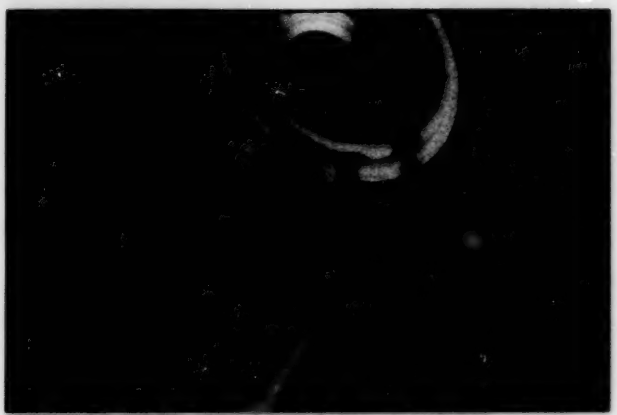
Figure 47. Kit for checking pressure gauge

have the gauge located on the selector valve. To check gauge reading accuracy, a second gauge may be temporarily attached to the boom and readings compared to the one mounted on the selector valve. Most new sprayers have the gauge connected so that it reads actual boom pressure. This is accomplished by running a small flexible line from a boom mid-point to the control location.

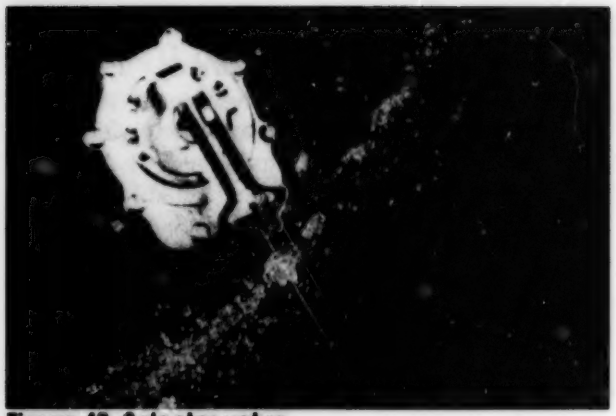
Figure 48. Selector valve

Pressure gauge accuracy check

1. Attach a hose equipped with a tire chuck to the sprayer gauge (figure 47).
2. Inflate a tire to 250 kPa. Check the pressure with a good tire pressure gauge.
3. Compare reading with sprayer pressure gauge.
4. Inflate the tire to 275 kPa and compare readings.

Boom Controls

The type of control valves used on a particular sprayer will depend on operating requirements and personal preferences.

Manual valves

Boom-control valves are used to regulate the flow of liquid. One of the most common is the three-section boom control. This type of control valve permits up to eight different spraying patterns (figure 48).

Electric solenoid valves

Electric solenoid valves are available in materials resistant to all common herbicides (figure 49). These valves may be mounted on the sprayer and controlled remotely from the driver's seat. Advantages include easier and faster control, a shorter and less complex plumbing system, and increased operator safety because there are no hoses with chemical near the operator. The pressure drop from the inlet to the spray line outlet is about 35 kPa with most electric solenoid valves.

A sprayer control system provides on/off control of sprayer booms and control of sprayer pressure from the seat of the tractor or truck cab (figure 50).

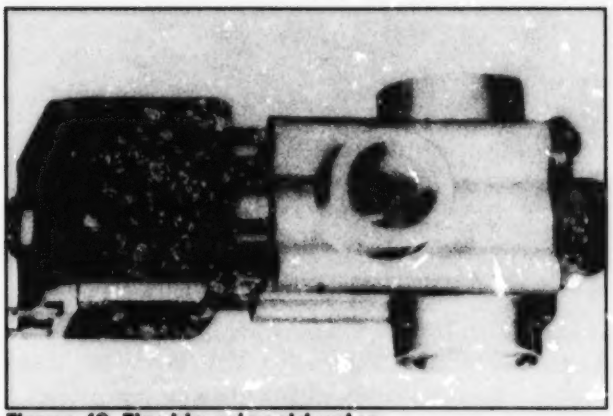

Figure 49. Electric solenoid valve

Figure 50. Remote boom and pressure control

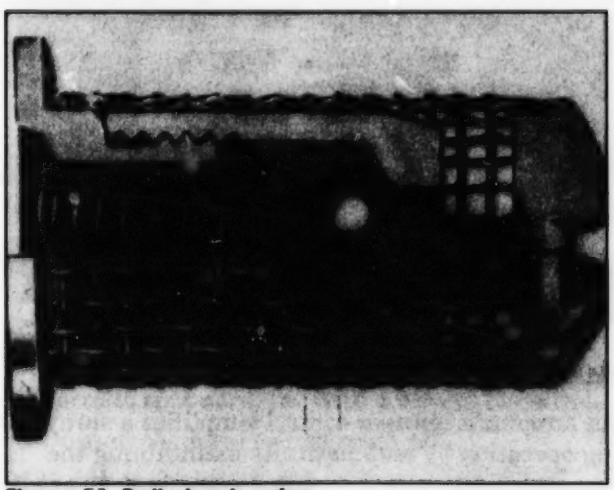

Figure 51. Ball check valve

Nozzle Check Valves

Nozzle check valves are used to prevent the spray solution from leaking out of the spray booms when the liquid pressure is shut off. This prevents the loss of spray material and helps avoid damage to crops and soils.

Ball check valves

Ball check valves are available as separate units but are usually incorporated into nozzle strainers (figure 51). Various operating pressures can be provided by selecting different springs. The most common ones open at 35 kPa, but 70, 140 and 280 kPa springs are also available.

When using ball check valves, the boom pressure must be increased by an amount equal to the valve opening pressure, to maintain the desired pressure at the nozzle tip. For example, if the desired nozzle pressure is 250 kPa and the ball check valves are equipped with 35 kPa springs, the boom pressure must be set at 285 kPa.

Since there is always a chance of error in manufacturing and also some variation in pressure drop with different nozzle sizes, it is best to check the pressure drop across all the ball check valves before checking the individual nozzle outputs. This can be done by measuring the pressure on both sides of the check valves with the sprayer operating. A special fitting is needed to measure the pressure between the ball check valve and the nozzle tip (figure 52). Any check valve that varies more than 10 kPa from the average should be discarded.

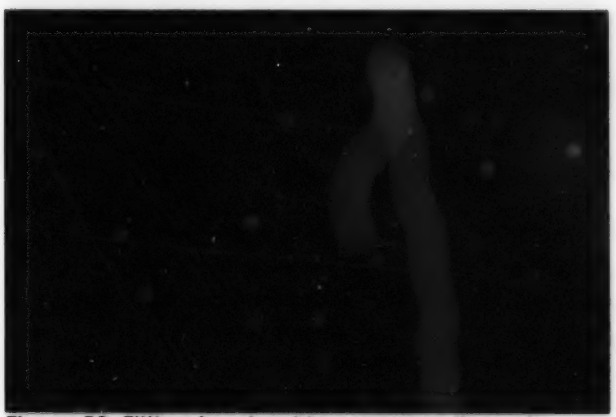

Figure 52. Fitting for checking pressure through checkvalves

Maintenance of ball check valves is often troublesome. Occasional flushing of the booms with a detergent solution will help to reduce sticking of the balls and also reduce leakage caused by foreign material lodged between the seat and the ball.

Diaphram check valves

Diaphragm check valves have several advantages over ball check valves (figure 53). They are less prone to sticking and erratic behavior and have no measurable pressure drop when operated within their recommended flow rates. Diaphram check valves are, however, more expensive than ball check valves.

The commonly available diaphragm check valves show no pressure drops at flow rates below three L/min. Valve opening pressures are typically about 50 to 60 kPa, but once the valve is opened, there is no measurable flow restriction at the flow rate given above. Therefore, boom pressure should not be increased as it is when using ball check valves. When using nozzles with higher outputs than those given above, the pressure drop across the check valve should be measured, and the boom pressure adjusted accordingly.

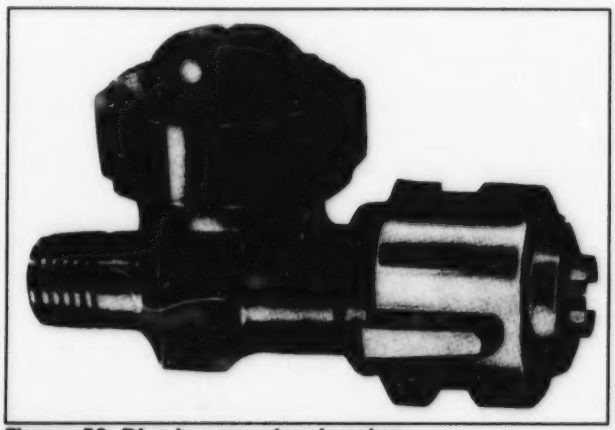

Figure 53. Diaphragm check valve

Flow Meters

Flow meters can be used to measure liquid flow (figure 54). The flow can be correlated with speed and distance travelled to determine the application rate. Flow meters should be mounted on the line to measure only the liquid flow to the spray booms or handgun. The bypass flow must not go through the flow meter.

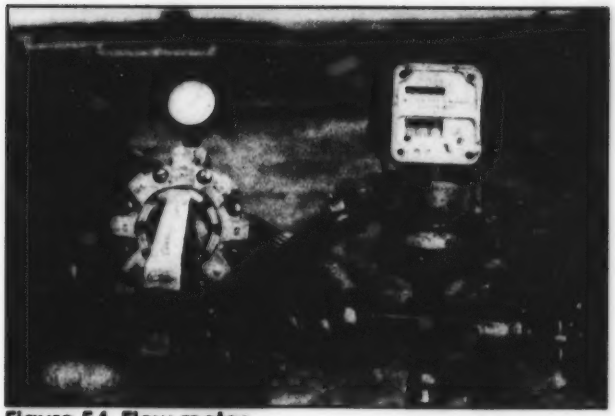

Figure 54. Flow meter

Sprayer Monitors

Electronic calibration is now available from several companies (figure 55). This is one of the most significant advances in spraying technology. With the use of electronic circuitry, it is possible to correlate liquid flow out of the booms with the forward speed of travel to display the application rate as a continual digital readout. These devices enable selection of the proper application rate and the operator simply adjusts the forward speed until correct application is achieved as indicated on the dial. Liquid flow is continuously measured, so any significant change in the spraying system such as excessive plugging, pump or regulator malfunction, or excessive leakage will show up instantly on the monitor.

Figure 55. Sprayer monitor

Automatic Sprayer Controllers

An automatic sprayer control simplifies a spraying operation by automatically maintaining the same application rate within recommended speed

ranges (figure 56). The system adjusts the liquid flow, so the application rate remains uniform throughout the field. The accurate operation of the system is based on having accurate flowing nozzles. Replace tips on a regular basis to ensure the system will maintain accurate rate control.

Figure 56. Automatic spray rate controller

Chemical Injectors

Chemical injectors have merit if properly designed with adequate controls and monitoring (figure 57). Separate tanks are provided for one or more chemicals and for the water supply.

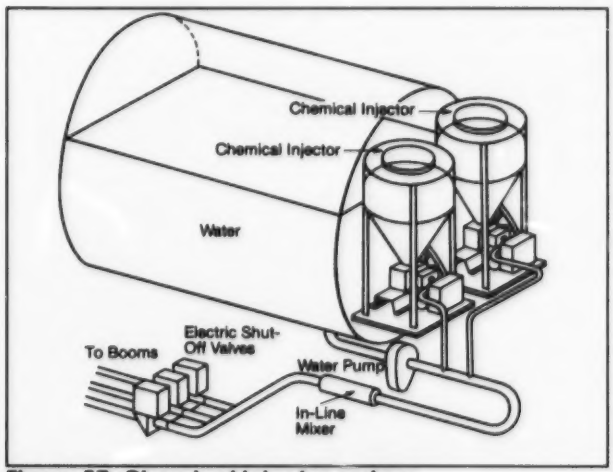

Figure 57. Chemical injector system

Advantages:

- Avoids pre-mixing of chemical and water
- Permits spot-spraying with a second chemical
- Unused chemical can be retrieved
- Weather shutdown does not waste chemical
- Safer for the sprayer operator
- Reduces chemical costs.

An adequate injection system will:

- Meter all chemicals at rates ranging from less than 0.1 L/min to more than 3.5 L/min.
- Meter chemical accurately, unaffected by chemical viscosity or composition.
- Maintain chemical application rate as travel speed changes.
- Maintain chemical application rate as a boom section is turned off or on.
- Be easy to adjust, calibrate and monitor.
- Have a quick response time for spot spraying with a second chemical.
- Provide uniform mixing of chemical with water.
- Be easy to empty and thoroughly clean the chemical metering system.

Caution: Only chemicals recommended for tank-mix application can be applied together.

Chemical injection systems added to conventional sprayers will likely require major changes to wet-boom pipe assemblies to reduce response time for spot applications. Response time acceptable to users have not been established, but current sprayers that are 24 metres wide with added injection systems may have a total response time in excess of one and a half minutes, depending on water application rate. Total response time is the time for the last nozzle on the boom to emit chemical. A one minute response time at a travel speed of eight kilometres per hour results in a travel distance of 134 metres before the last nozzle on a 20 nozzle boom, with nozzles spaced 0.5 metres apart will emit chemical.

Strainers

Filtration should be operated in stages, starting with a coarse mesh and progressing to finer screens at strategic points along the direction of flow. The mesh sizes selected will depend upon the rate of flow of the liquid, and the nature of the chemicals in it.

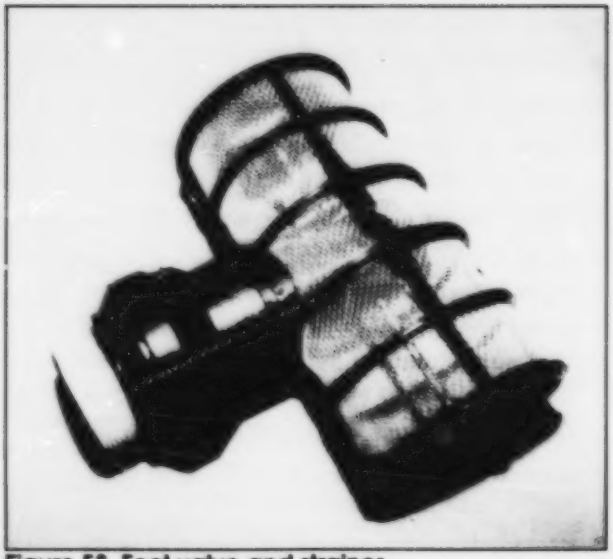

Figure 58. Foot valve and strainer

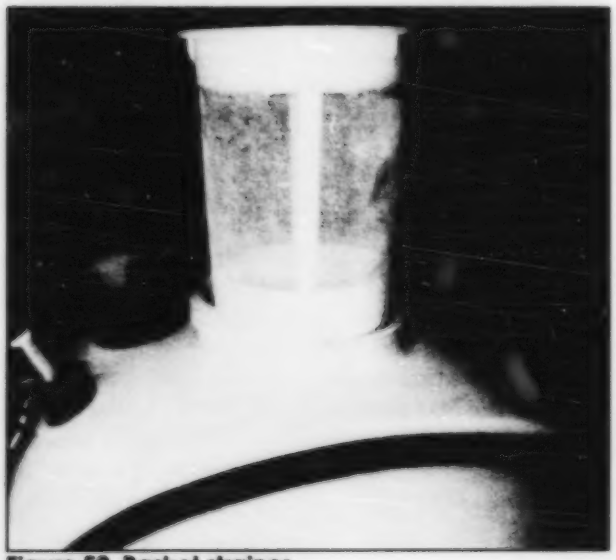

Figure 59. Basket strainer

Tank Strainers

Filtration into the tank is through the foot valve and strainer (figure 58) or the basket strainer (figure 59). An 80 or 100 mesh screen should be used in the tank filler opening. This will effectively pre-screen the material before it enters the tank.

Pump Strainers

The filtration between the tank outlet and the pump by means of the suction strainer provides

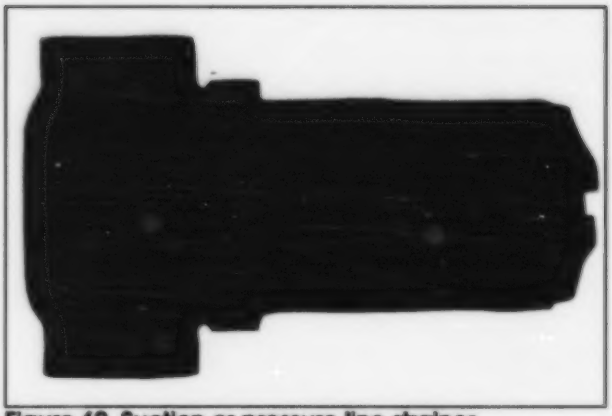

Figure 60. Suction or pressure line strainer

protection for the pump (figure 60). This filter is located between the tank and the pump when using roller, piston and diaphragm pumps and located between the pump and booms when using a centrifugal pump. The reason for this is that the centrifugal pump can handle foreign material without damage. By having the filter between the pump and booms, a much smaller volume of tank solution is filtered. A 50 or 60 mesh filter is satisfactory for most solutions. Wettable powders require a 50 mesh filter. To maintain efficient filtration without restricting liquid flow, the screen area should be as large as possible, with adequate clearance around the element in the filter housing.

Felt filters have been replaced by metal screen filters because they provide more filter area, are easier to clean, and they handle wettable powders.

Pressure line strainers are the most efficient pressure filters (figure 60). These are fitted either:

- Between the pump and the pressure regulator, requiring one large pressure line strainer.
- In each hose, feeding the individual spray boom sections.

Nozzle Strainers

To help prevent nozzle tips from plugging, nozzle-tip strainers are recommended (figure 61). The strainer stops dirt and other particles before they can plug the orifice. The size of strainer depends on the tip size and the type of solution. A 50 mesh screen or equivalent slotted strainer is normally sufficient for larger tips (02 and up) and

Figure 61. Nozzle strainer

for wettable powders. An 80 or 100 mesh screen is normally used with smaller tips.

Always check whether the chemical manufacturer has made filtration recommendations on the label.

Precautions

- Loss of flow and/or pressure is often the result of blocked filters. Clean them regularly. Carefully observe safety precautions for handling contaminants.
- Excessively fine filtration can cause a proportion of certain wettable powders to be 'screened off'. The chemical manufacturer's recommendations should always be checked.
- Mesh size refers to the number of holes per 25 millimetres.

Note: Filters should be located where the risk of damage to the filter is minimized and where access for cleaning is not inhibited.

Agitation Systems

Intense agitation is required to keep some chemicals in suspension. The return flow from the pressure regulator does not normally provide enough agitation, especially when the pump output drops off. To ensure adequate agitation for all chemicals, a mechanical or jet agitator should be used in the tank. Although mechanical agitators provide the most positive mixing, a jet agitator is probably easier to install in most existing sprayers. Sparge tube agitators may also be used.

Using only the by-pass return liquid to provide agitation is often inadequate even with full pump output, and as the output decreases the amount of return liquid decreases, thus providing less agitation. No indication of low pump output is given with this system until the return liquid drops to zero.

Mechanical Agitation

Mechanical agitation can be provided by paddle wheels or propellers driven by electric motors or power shafts from the tractor (figure 62). Mechanical agitation provides the most positive and thorough mixing possible. The added expense makes them impractical for most farm-type sprayers but they are common on commercial, high pressure, utility sprayers.

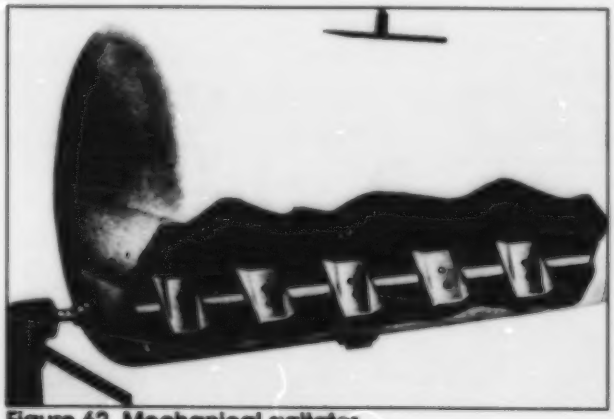

Figure 62. Mechanical agitator

Sparge Tube Agitation

Sparge tubes consist of a perforated pipe or pipes running the length of the tank (figure 63). The pipe is connected to a pressure line and liquid pumped through it sweeps the bottom of the tank. These devices must not be connected to the bypass because excessive pressure would build up when the booms are turned off. Although sparge tubes do not increase the quantity of liquid in circulation, they do provide uniform agitation throughout the tank.

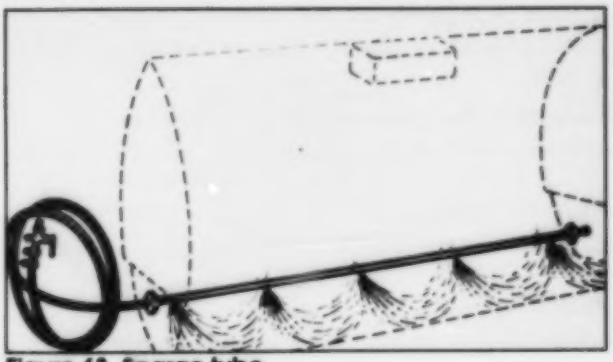

Figure 63. Sparge tube

Jet Agitation

Jet agitators with venturi caps have an output of two or three times their input (figure 64). Various sizes are available for different sizes and shapes of tanks. A per minute input of about one to two per cent of the tank capacity is recommended.

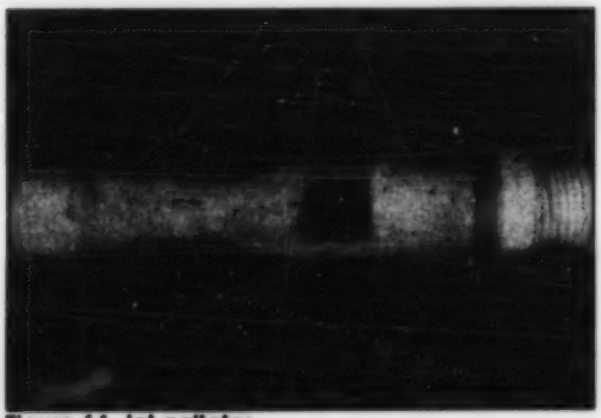

Figure 64. Jet agitator

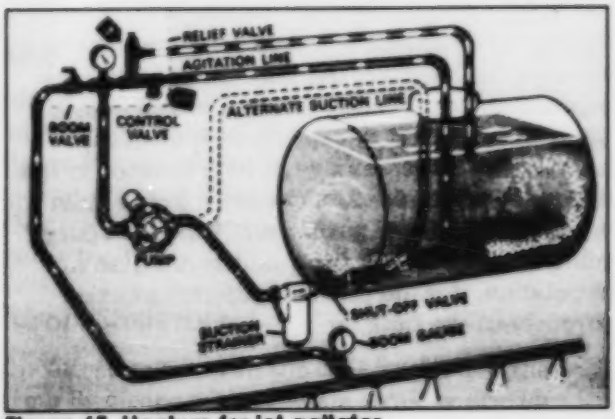

Figure 65. Hookup for jet agitator

To get adequate mixing of wettable powders, several nozzles are required to get a complete sweep of the tank bottom. Large flat bottom tanks need more nozzles than do round tanks.

Jet agitators must never be connected to the return line from the pressure regulator because excessive pressure will occur when spray lines are shut off (figure 65).

Jet agitators must be securely fastened inside the tank to prevent whipping. A throttling valve should be provided in the agitator line to reduce the flow if excess foaming occurs.

To adjust for spraying, close the agitator control valve and open the boom valve. Adjust the relief valve until the pressure gauge reads 75 to 100 kPa above the desired spraying pressure. Slowly open the agitator control valve until spraying pressure is reached. If the pressure won't come down even with the control valve wide open, use a larger orifice in the agitator.

Boom Systems

Agricultural Booms

The boom is usually made of aluminum owing to its light weight; however, galvanized steel pipe is also used because of its higher strength. The pipe size depends on sprayer width and application rates. A 25 millimetre diameter pipe is normally satisfactory for larger sprayers while a 20 millimetre tube is sufficient for smaller ones (table 10).

The boom of a sprayer is normally mounted on a support to provide stability and to maintain correct boom height (figure 66). Whipping, either

Figure 66. Conventional boom

horizontal or vertical, can result in changes in application rate of 25 to 30 per cent at the boom end when the wheel goes over a five centimetre bump. Castering boom support wheels should be locked into position to provide more directional stability. Locking in transport is also necessary to avoid the wheel whip experienced with the non-rigid support of caster wheels. The maximum width of sprayer booms that will give good coverage depends on the levelness of the fields. In areas with rolling land, ravines and short steep slopes, the use of very wide sprayers should be avoided. In these situations, it is impossible to maintain correct boom height with a very wide boom. The height of the boom should be easily adjustable between 25 and 100 centimetres or higher. A convenient adjustment is necessary to allow spraying at a forward angle of 45° without the spray hitting the boom wheels or frame. Booms should fold easily for transportation.

Many tractor-mounted and truck-mounted sprayers come equipped with booms that do not have outrigger wheels. Booms without wheels, supported by chains or cables, tend to bounce and dig into the ground while turning in the field. The newer types of booms are trapeze mounted and more stable than chain supported booms, especially in rough fields (figure 67). A skid is mounted on the outer ends of these booms to prevent the nozzles from contacting the soil surface.

Booms must be stable. Unstable booms produce an erratic spray pattern, which results in uneven pest control and/or crop damage. Poorly supported booms and booms that are too long will "whip" in the field. Two types of boom whip encountered are vertical and horizontal.

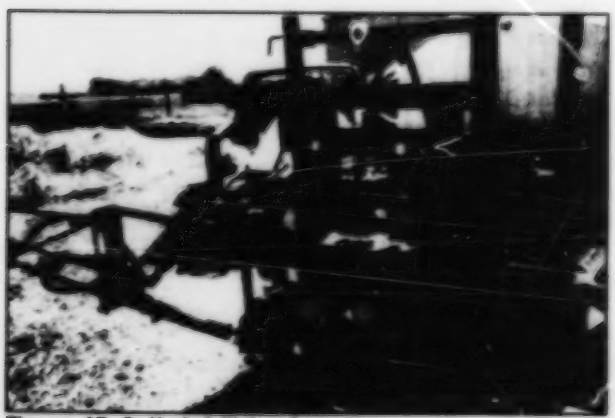

Figure 67. Self-stabilizing boom

Vertical boom whip

On uneven ground, the ends of long, unsupported booms whip up and down (figure 68). This produces uneven application. Outrigger wheels will reduce vertical whip to a minimum.

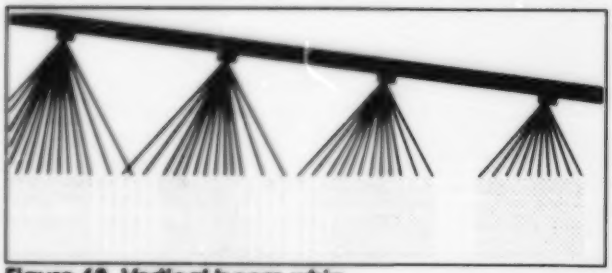

Figure 68. Vertical boom whip

Horizontal boom whip

Rough ground, poorly braced booms, and a loose hitch between the sprayer and tractor can combine to give horizontal boom whip (figure 69). This will produce a patchy spray pattern. Stabilizer bars, a securely pinned drawbar and a ball and socket hitch will help to eliminate horizontal whip.

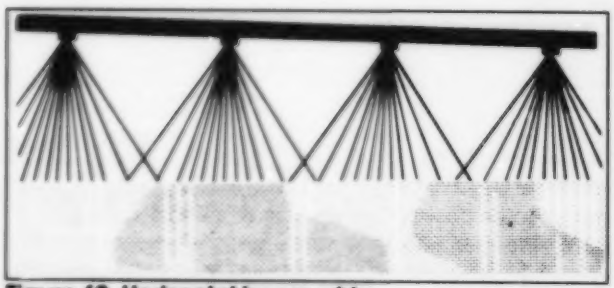

Figure 69. Horizontal boom whip

Roadside Spraying Booms

A variety of hydraulic booms are used by municipalities for roadside spraying. Some districts use off-centre nozzles or accutrol nozzles as a boomless type of spraying system. The boomless systems are less costly than hydraulic articulating booms, however, the spray distribution is not as uniform; the spray swath is limited and boomless systems are more prone to create drift.

Articulating booms

Regardless of roadside terrain, from ditches to almost vertical banks, a contour-matic three

Figure 70. Contour boom (side mount)

Figure 71. Contour boom (front mount)

section boom can be articulated into many configurations (figures 70, 71). You can have straight angle up or down, L shape up or down, Z shape up or down or whatever you need to place the spray nozzles close to the foliage being sprayed. A contour-matic boom is controlled hydraulically and has a seated control position adjacent to the inboard end of the boom for easy and accurate operation. In-cab controls can also be installed.

Eight-metre or 10-metre wide booms are available. An off-centre nozzle mounted on the end section can provide coverage to a maximum of 15 metres.

Boom with off-centre nozzles

This is a hydraulic operated boom that can be controlled from inside the truck cab. One off-centre nozzle covers the portion of ditch next to the road (figure 72) while the second off-centre nozzle at boom end provides extended coverage into the roadside ditch up to 12 metres (figure 73).

Figure 72. First nozzle on off-centre nozzle boom

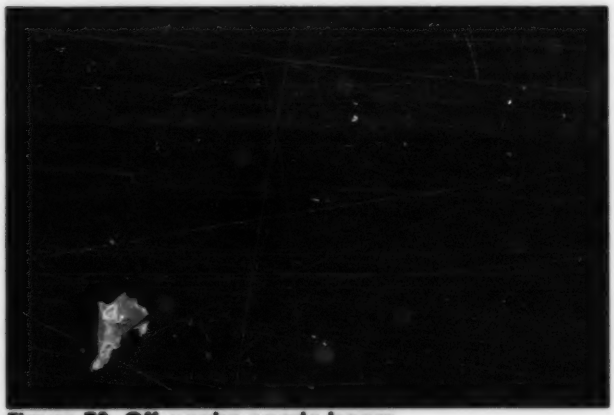

Figure 73. Off-centre nozzle boom

Handgun Sprayers

The handgun sprayer is a convenient accessory to the field or truck mounted sprayer for jobs that are too big for self-contained hand sprayers, or where large amounts of solution are required to wet the foliage.

The handgun consists of the gun and a length of hose. It is used during field spraying to treat patches of weeds in locations inaccessible to the tractor and sprayer, or to spray areas where weeds or brush are too high to go over with the sprayer itself. Handguns can be easily added to a standard field sprayer.

Hooking Up A Handgun

A minimum amount of plumbing is required to hook up a handgun. Once the connection to the outlet line is made, it may be permanently left in place (figure 74).

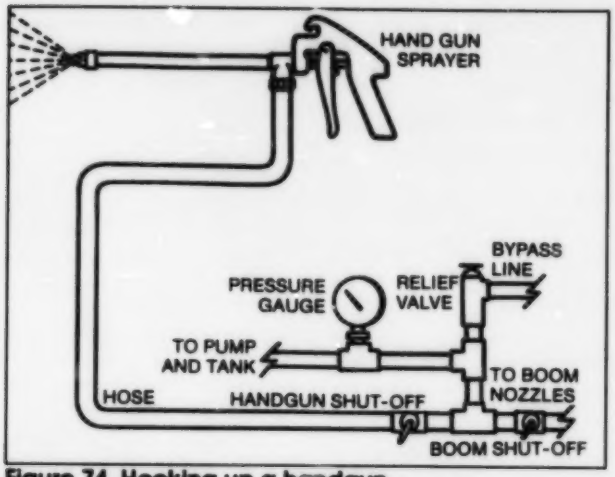

Figure 74. Hooking up a handgun

- Installation should be made in a line between the pump and the boom. If a selector valve is present, the installation can be made right at the valve.

If other types of valves are used, the connection should be between the valve and one boom section.

- A tee is installed at some convenient point between the pump and boom.
- A nipple is installed in the tee leading to a shut-off valve.
- A nipple is installed on the other side of the shut-off valve, leading to a hose connector.
- A hose, at least eight metres in length and leading to the handgun, is hooked into the system at the hose connector.
- To complete the hook up, a shut-off valve should be installed between the tee and the boom.

How To Use A Handgun

Controlling weeds with a handgun requires a relatively high volume of spray solution. It is essential that weed foliage is thoroughly covered to the point of run off.

Output from a handgun depends upon:

- Size of orifice disc in handgun.
- The pressure at the gun.
- The spraying habits of the gun operator. The whole operation is completely manual so the output depends upon how long the operator sprays a weed patch.

Table 11. Handgun Orifice Disc Output Capacity at Various Pressures

Disc orifice	Capacity L/min			
size	500 kPa	1000 kPa	1500 kPa	2500 kPa
4	2.74	3.87	4.74	6.12
5	4.10	5.80	7.10	9.17
6	5.70	8.06	9.87	12.70
7	7.52	10.60	13.00	16.80
8	9.80	13.90	17.00	21.90

Precautions

Three precautions are suggested when using a handgun:

- Thoroughly clean the gun between jobs because the hose can contain a substantial amount of pesticide mixture.
- Precise calibration is difficult, so handguns should be used for applications when accurate rates are not required. For example, herbicides are generally applied with a handgun by mixing a very dilute solution and applying to the point of runoff.
- Pressure and water volume are the factors that allow us to reach the target. For water particles to carry they must have mass, so there are limits to the maximum pressure used to increase the throw or carry of a water stream (table 12).

Always use a large enough hose and a nozzle disc to permit as much pump capacity as possible to be used.

Table 12. Volume and Distance Achieved with Various Orifice Sizes

Orifice	700 kPa		5600 kPa	
size	L/min	m	L/min	m
D-2	2.0	10.0	5	10.5
D-4	3.5	11.0	10	12.0
D6	7.5	13.5	21	15.0
D-8	13.0	14.0	36	15.5

Sprayer Nozzles

Nozzle-body Assemblies

Wet-boom nozzle bodies

The majority of field sprayers used in Western Canada are classed as "wet boom" sprayers. This means that the liquid is supplied to the nozzle tips through a pipe. The nozzle tips are attached to the pipe at a 50-centimetre spacing. The spacing is not adjustable. The older-style nozzle body had a threaded cap to hold the nozzle tip in place. These nozzle bodies are usually made from brass and are held in place with a stainless steel or plastic pipe clamp.

Newer designs of nozzle bodies and boom clamps are generally manufactured from nylon regardless of the manufacturer. The new designs have a quick connect nozzle cap, which only requires a quarter turn to attach or to remove the nozzle cap. This feature makes it easy to remove tips and strainers for changing or cleaning (figure 75).

The newer design nozzle caps have another advantage over the threaded style. The nozzle tips fits into a slot in the cap, thus becoming self aligning. This automatic aligning feature ensures that the spray patterns from adjacent nozzles do not hit each other and distort the pattern in the overlap area (figure 76). The new design of nozzle body is also available with a diaphragm check valve to prevent the nozzle from dripping when the sprayer is shut off (figure 77).

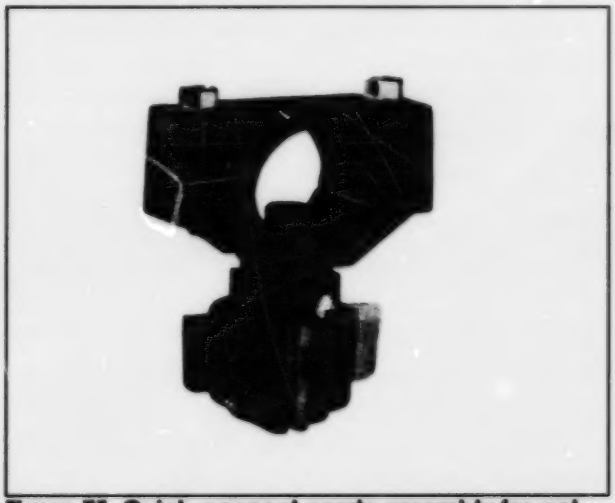

Figure 75. Quick-connect nozzle assembly for wet boom

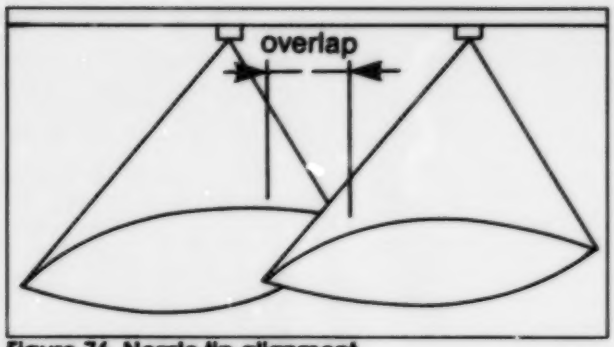

Figure 76. Nozzle tip alignment

Figure 77. Quick connect with diaphragm for wet boom

Dry-boom nozzle bodies

Dry-boom assemblies were originally designed for spraying row crops of various spacings. For this reason the nozzle spacing had to be adjustable. Pipe and round or square tubing are used to support the nozzles and the liquid is fed through hoses to the nozzles (figures 78, 79).

Nozzle Tips

The successful performance of a crop chemical is highly dependent on proper application as recommended by the chemical manufacturer. Proper selection and operation of spray nozzles are important steps in accurate chemical application. The volume of spray passing through each nozzle plus the droplet size and spray distribution on the target can influence pest control. The spray tip orifice is critical for controlling these three factors. As a nozzle tip wears, the spray pattern distorts, the output volume increases and the droplet characteristics change.

Recalibration may correct output changes, but it cannot correct for spray pattern changes. Poor

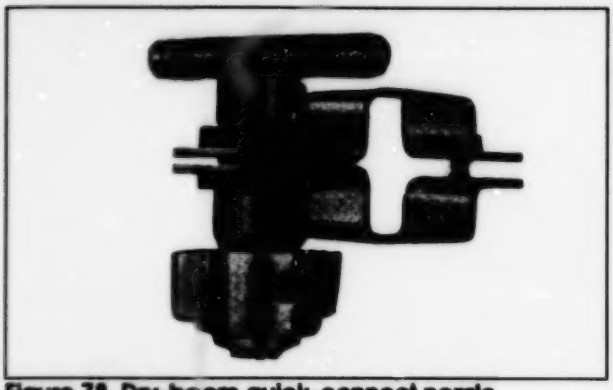

Figure 78. Dry-boom quick-connect nozzle assembly

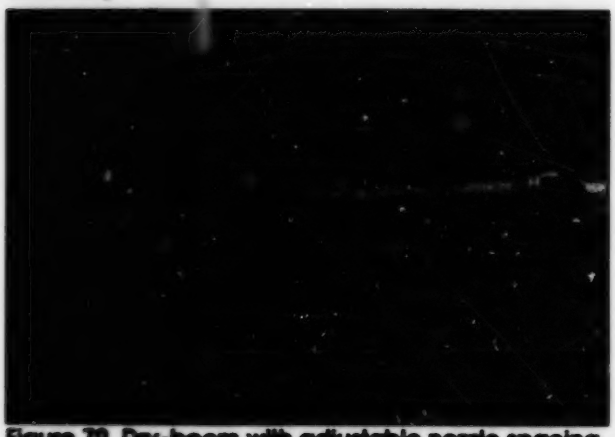

Figure 79. Dry-boom with adjustable nozzle spacing

Figure 80. Partially plugged tip

spray distribution is preventable. Selection of longer wearing tip materials or frequent replacement of tips that are made of softer materials can eliminate misapplication caused by worn spray tips.

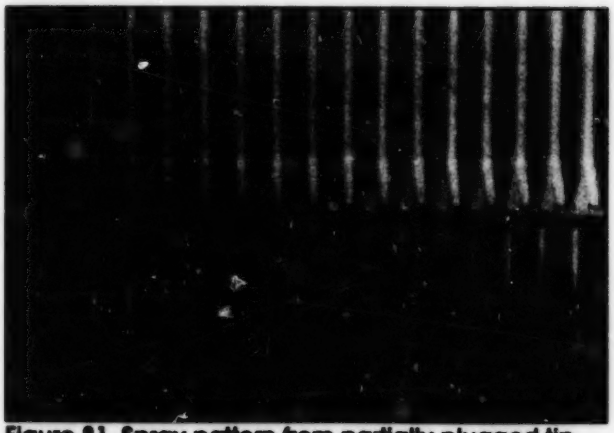

Figure 81. Spray pattern from partially plugged tip. Note the rightside of pattern

Careful cleaning of a plugged spray tip can mean the difference between a clean field and one with spray misses (figure 80, 81). Flat spray tips have finely machined thin edges around the orifice to control the spray. Even the slightest damage from improper cleaning can cause both an increased flow rate and poor spray distribution. Be sure to use adequate strainers in your spray system to minimize plugging. If a tip does plug, use a soft bristled brush or toothpick to clean it; never use a metal object. Use extreme care with soft tip materials. Experience has shown that even a wooden toothpick can distort the orifice (figure 82, 83, 84).

Tip materials

Nozzle tips are manufactured from many different materials. The most commonly used materials are stainless steel, nylon and brass. Hardened stainless steel and ceramic tips are used where extra long life is desired when very abrasive chemicals are applied. Other materials used are acetal copolymer, aluminum oxide and aluminum.

Nozzle Types

There are five main types of nozzles; flat-fan, even-fan, flooding-fan, cone nozzles, and off-centre nozzles. Accutrol nozzles, the radiarc spray system and controlled droplet applicators are designed for non-agricultural use.

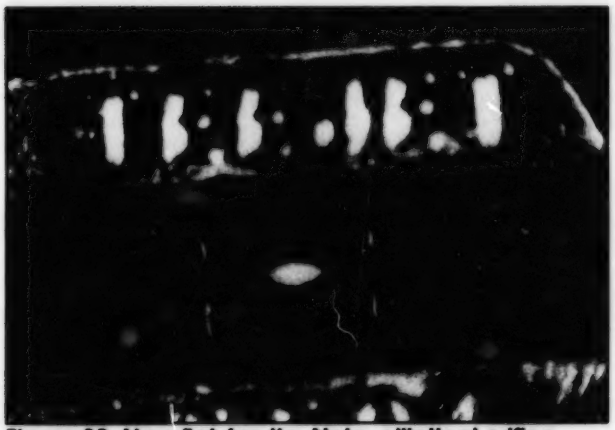

Figure 82. New flat-fan tip. Note: elliptical orifice

Figure 83. Orifice damaged by wire that was used to unplug nozzle

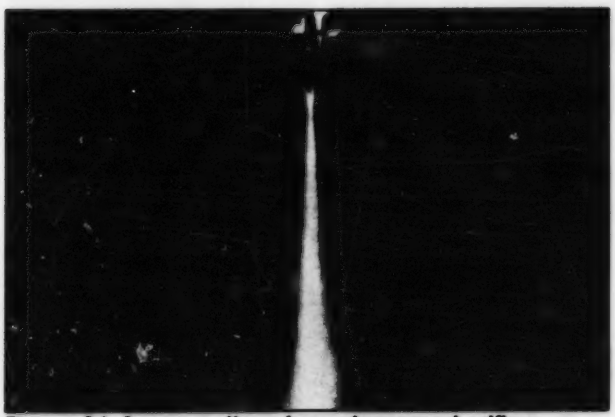

Figure 84. Spray pattern from damaged orifice

Flat-fan Nozzles

The ideal sprayer delivers even coverage over the whole field with a spray consisting of small droplets. Large droplets give insufficient coverage and very fine drops are subject to drift. The

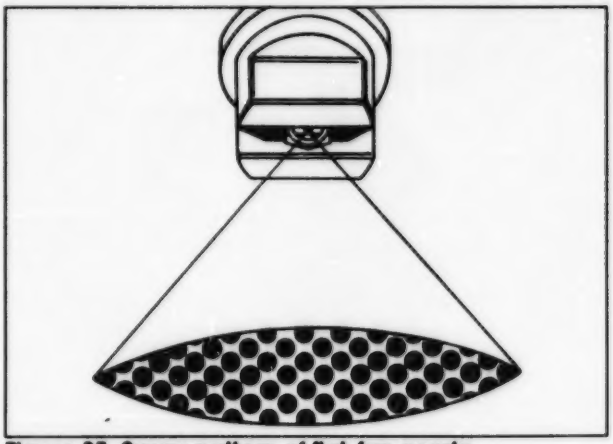

Figure 85. Spray pattern of flat-fan nozzle

Figure 86. Spray from one flat-fan nozzle collected in pattern tester. Note the tapered edges of pattern.

pattern of spray droplets on the target is created by a combination of the following three factors: nozzle type, pressure, and boom height.

The flat-fan spray tip is the most common tip used for broadcast spraying. Its droplet and spray pattern characteristics produce a relatively uniform spray coverage.

The tapered flat-fan nozzle used for broadcast spraying produces a pattern heavier at the centre than at the edges (figures 85, 86). This nozzle is operated with the spray fans of adjacent nozzles overlapping to fill in the light areas and give a uniform pattern (figures 87, 88, 89). The flat-fan nozzle is available in a wide range of sizes and in several spray angles (table 15).

With any of the flat-fan nozzles, the rated spray angle is produced at only one pressure setting, i.e. 275 kPa. Increasing the pressure will produce a wider pattern and smaller droplets, decreasing

Figure 87. Spray pattern from two flat fan nozzles

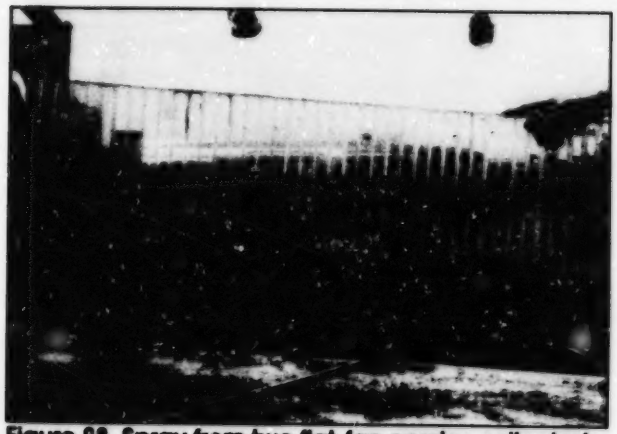

Figure 88. Spray from two flat-fan nozzles collected in pattern tester. Note the centre area of pattern is flat indicating correct height above target.

Figure 89. Boom set too low. Note the dip in centre of pattern

the pressure will produce a narrower pattern and larger droplets. Because each nozzle is designed to operate over a narrow pressure range and the

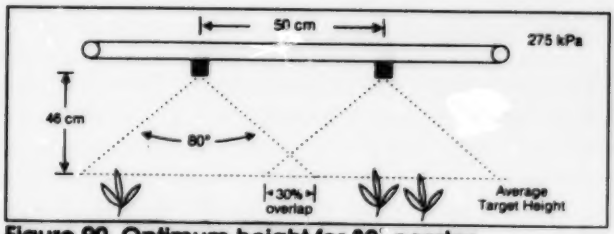

Figure 90. Optimum height for 80° nozzles

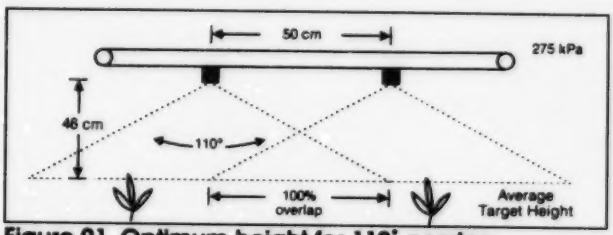

Figure 91. Optimum height for 110° nozzles

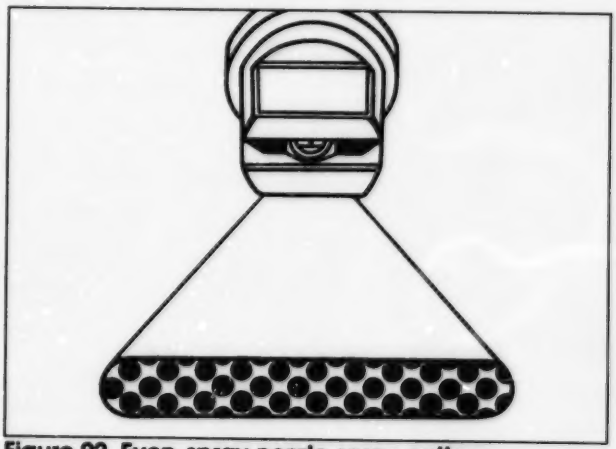

Figure 92. Even-spray nozzle spray pattern

nozzle spacing along the boom is fixed on most sprayers, all pattern adjustments are made by changing the height of the nozzle above the target (table 13). The targets for post-emergent herbicides are the weeds, while for soil-applied herbicides, the target is the ground.

Extended Range (XR) Flat-fan Nozzles

Variable pressure spray tips, commonly known as extended range (XR) tips, will produce acceptable patterns at pressures as low as 100 kPa. They can also be operated at pressures as high as 300 kPa if desired. They are available with two different spray angles – 80 and 110°.

Even-spray Nozzles

The even-spray tip is identical to the flat-spray tip except it does not produce a tapered edge pattern (figure 92). As a result, this tip is not used for broadcast spraying owing to excessive spray coverage if overlap should occur. It is primarily used to band-spray row crops. (figure 93)

The even-spray tips are identified by the letter "E" in the tip designation (e.g. 8001E). See table 17. Even-spray tips have the same output as a flat spray tip with the same volume designation. However, when band spraying occurs, any nozzle tip will apply various volumes per acre depending on row spacing and the width of the band actually sprayed. The width of the band required can be controlled by adjusting the nozzle height above the target (table 18).

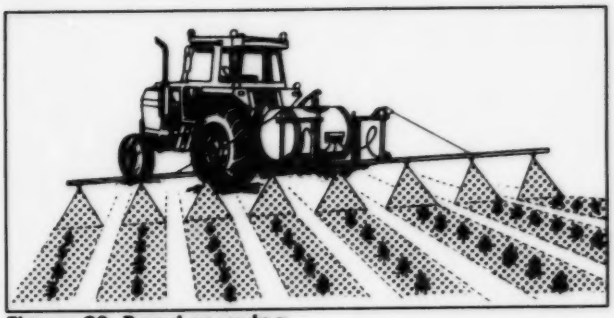

Figure 93. Band spraying

Flooding-fan Nozzles

Flooding-fan tips apply liquid fertilizers and other chemicals that do not require precision application (figure 94). These tips are a variation of the even edge design with the spray angle extended to 110° - 145° (table 19). The spray deposit is concentrated at the edges of the pattern when overlapping. The round orifices on flooding tips are less likely to plug than the elliptical orifices found on other flat-fan tips, but the patterns pro-

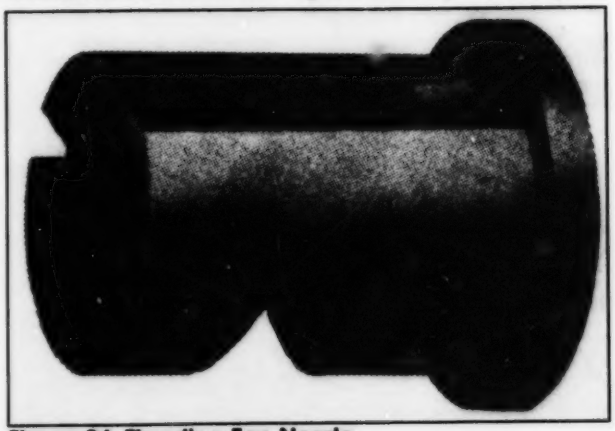

Figure 94. Flooding Fan Nozzle

Table 13. Recommended Pressures and Heights for Standard and XR Tips.

Nozzle type	Pressure range kPa	Recommended height above target 50 cm spacing cm	75 cm spacing cm
80° flat fan	200 - 300	45 - 50	70 - 75
110° flat fan	200 - 300	45	40 or 60
80° extended range	100 - 300	40	65 - 70
110° extended range	100 - 300	25 or 45	40 or 60

Table 14.TeeJet Flat-fan Nozzle Tips and Nearest Equivalents

TeeJet	Delavan	Lurmark	Hardi
11001	LF 1 - 110°	01 F 110	4110 - 10
100015	LF 1.5 - 110°	015 F 110	4110 - 12
11002	LF 2 - 110°	02 F 110	4110 - 14
11003	LF 3 - 110°	03 F 110	4110 - 16
11004	LF 4 - 110°	04 F 110	4110 - 20
11005	LF 5 - 110°	05 F 110	4110 - 24
11006	LF 6 - 110°	06 F 110	—
11008	LF 8 - 110°	08 F 110	4110 - 30
11010	LF 10 - 110°	10 F 110	—

In this case the nozzle numbers listed are the 110 degree spray angle (i.e. 11001). Eighty degree nozzles would be designated as 8001, LF1-80, 01F80.

duced by flooding tips vary greatly with pressure, material being sprayed, and tip size. Therefore, general recommendations cannot be made regarding the best heights, pressures or spacings, except that spacings should not exceed 1.5 metres and pressures should normally be between 150 and 300 kPa. The mounting angle of flooding tips can be varied to obtain different directions of delivery. A straight down delivery produces the least spray drift potential but the worst pattern while a horizontal delivery produces a better pattern but more spray drift potential. Because of the generally uneven patterns produced by flooding nozzles, they should not be used for herbicides unless specifically recommended by the manufacturer.

Table 15. Flat-fan Nozzle Output Table

Nozzle	Pressure	Volume	Litres per acre at 50 cm nozzle spacing						
tip	kPa	L/min	6 km/h	7 km/h	8 km/h	9 km/h	10 km/h	11 km/h	12 km/h
	200	.32	26	22	20	17	16	14	13
11001	275	.38	30	26	23	20	18	16	15
	300	.39	32	27	24	21	19	17	16
	200	.48	39	33	29	26	23	21	20
110015	275	.57	46	39	35	31	28	25	23
	300	.59	48	41	36	32	29	26	24
	200	.65	53	44	40	34	32	28	26
11002	275	.76	62	52	46	40	36	32	30
	300	.79	64	54	48	42	38	34	32
	200	.97	79	68	59	53	47	43	40
11003	275	1.15	93	80	70	62	57	51	47
	300	1.18	96	82	72	64	58	52	48
	200	1.30	105	88	80	68	64	56	52
11004	275	1.52	123	104	92	80	72	64	60
	300	1.58	128	108	96	84	76	68	64
	200	1.61	130	111	96	87	78	71	65
11005	275	1.89	153	131	114	102	92	83	77
	300	1.97	159	136	119	106	95	88	80
	200	1.93	15	136	118	106	94	86	80
11006	275	2.30	185	160	140	122	112	102	94
	300	2.37	191	164	144	128	116	104	96
	200	2.58	209	176	160	136	128	112	104
11008	275	3.04	246	208	184	160	144	128	120
	300	3.16	255	216	192	168	152	136	128
	200	3.22	261	222	192	174	156	142	130
11010	275	3.78	306	262	228	204	184	166	144
	300	3.95	320	272	238	212	190	176	160

Table 16. Extended Range Flat-fan Nozzle Output Chart

Nozzle tip	Pressure		Litres /ac at 50 cm spacing				
			8	9	10	11	12
	kPa	L/min	km/h	km/h	km/h	km/h	km/h
XR11001	100	.23	13	12	10	9	8
	275	.38	23	20	18	17	15
XR110015	100	.35	21	19	17	15	14
	275	.56	34	30	27	25	23
XR11002	100	.44	27	24	22	20	18
	275	.76	46	41	37	33	31
XR11003	100	.68	41	36	33	30	27
	275	1.12	68	60	54	49	45
XR11004	100	.92	56	50	45	41	37
	275	1.50	91	81	73	66	61
XR11005	100	1.18	72	64	58	52	48
	275	1.89	115	102	92	84	77
XR11006	100	1.39	84	75	67	61	56
	275	2.28	138	123	110	100	92
XR11008	100	1.86	113	100	90	82	75

Cone Nozzles

Hollow-cone and solid-cone nozzles are used primarily for spraying insecticides and fungicides in row crops (figures 95, 96). Hollow cones are used when low-volume applications of fine droplets are needed for thorough coverage. Solid cones are best suited for high-volume applications where dense foliage requires a penetrating spray. These nozzles operate best at high pressures (550 kPa or greater) and are often used in drop tube configurations. They wear well when using wettable powders and other abrasive chemicals. Because the nozzles do not produce a uniform spray pattern, they are not used in broadcast herbicide applications. Some types such as Raindrop and Whirl Jet nozzles produce larger droplets that are resistant to drift but provide poor spray coverage (figure 97).

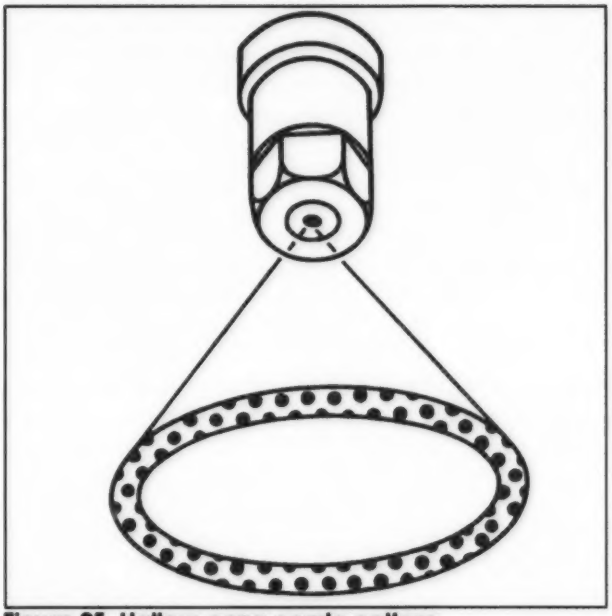

Figure 95. Hollow-cone nozzle pattern

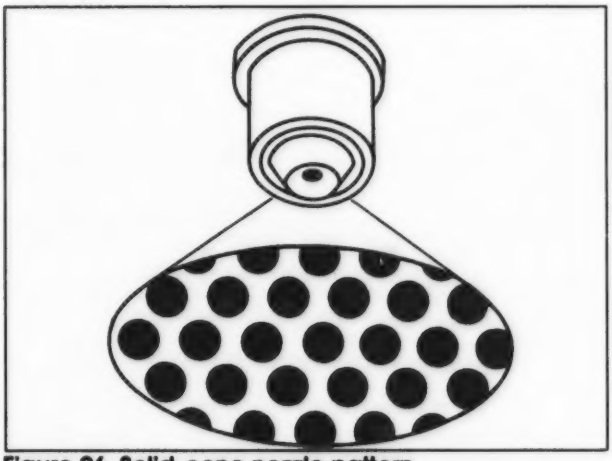

Figure 96. Solid-cone nozzle pattern

Table 17. Even-fan Nozzle Output

Nozzle tip	Pressure	L/min
8001E	150	.28
	200	.32
	275	.38
80015E	150	.42
	200	.48
	275	.57
8002E	150	.56
	200	.65
	275	.76
8003E	150	.84
	200	.97
	275	1.13
8004E	150	1.12
	200	1.29
	275	1.51
8005E	150	1.40
	200	1.61
	275	1.89
8006E	150	1.67
	200	1.93
	275	2.27
8008E	150	2.23
	200	2.58

Table 18. Nozzle Heights for Various Band Widths and Spray Angles

	Nozzle spray angle			
Band width	40°	80°	95°	110°
cm	Nozzle height cm			
20	27	12	9	7
25	34	15	12	9
30	41	18	14	11
35	48	21	16	13

Figure 97. Raindrop nozzle

Off-centre Nozzles

Off-centre nozzles are usually referred to as boom-end nozzles (figure 98). Most field sprayers come equipped with these nozzles and have a shut-off valve provided. Off-centre nozzles should not be used for overall herbicide application in crops because the spray pattern is not uniform. These nozzles should be used only on headlands, slough areas and fencelines to provide extended coverage where the boom nozzles cannot reach. The coverage extends from one to three metres depending on nozzle size, pressure and wind conditions. Drift can be very pronounced with these nozzles.

Large capacity off-centre nozzles are designed to provide a boomless spray and are used for spraying roadside ditches, pastures and other areas too rough for boom sprayers or where there are many obstacles such as brush and fences (figure 99). These nozzles provide coverage up to 10 metres depending on nozzle size, pressure and wind conditions.

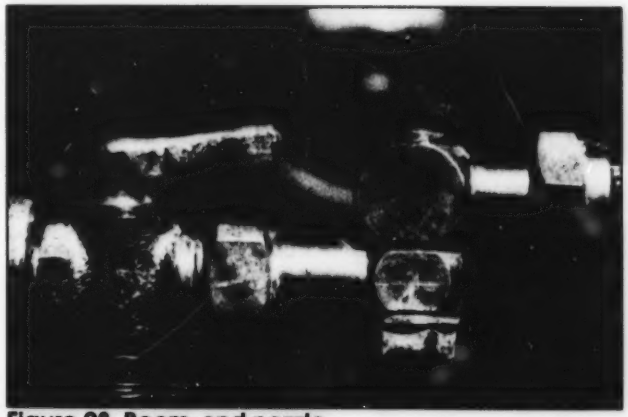

Figure 98. Boom-end nozzle

Figure 99. Large off-centre nozzle

Table 19. Flooding-fan Nozzle Output Table

Nozzle No TeeJet	Delavan	Pressure kPa	Volume L/min	Litres per acre at 100 cm spacing 6 km/h	8 km/h	9 km/h	10 km/h
TK .75	D 75	250	.54	22	17	15	13
		275	.57	23	18	16	14
TK 1	D 1	250	.72	29	22	19	17
		275	.78	31	23	21	19
TK 1.5	D 1.5	250	1.08	44	33	29	26
		275	1.13	46	35	31	28
TK 2	D 2	250	1.44	58	44	39	35
		275	1.51	61	46	41	37
TK 2.5	D 2.5	250	1.80	73	55	49	44
		275	1.89	77	58	51	46
TK 3	D 3	250	2.16	89	67	59	53
		275	2.26	93	70	62	56

Table 20. Raindrop Nozzle Output Table

Nozzle number	Pressure kPa	Volume L/min	Litres per acre at 50 cm spacing 6 km/h	8 km/h	10 km/h
RA 2	200	.64	52	39	31
	275	.76	61	46	37
RA 4	200	1.29	104	78	63
	275	1.51	122	92	73
RA 5	200	1.61	130	98	78
	275	1.89	153	115	92
RA 6	200	1.93	157	117	94
	275	2.27	183	138	110
RA 8	200	2.58	209	157	125
	275	3.02	245	183	147
RA 10	200	3.22	261	195	157
	275	3.78	306	229	183
RA 15	200	4.84	397	297	238
	275	5.67	461	346	277

A combination of two large off-centre nozzles mounted together form a single unit called a boomjet nozzle for spraying in rough pasture and rangeland (figure 100). This system can be mounted behind a truck, tractor or trailer sprayer and can cover up to 18 metres.

Accutrol Nozzles

These nozzles are designed for industrial uses such as spraying roadsides or other rights-of-way. Accutrol nozzles are designed to be used in combination with a spray adjuvant. The nozzle draws in air and mixes it with the spray to form a milky mixture resembling foam that is visible to

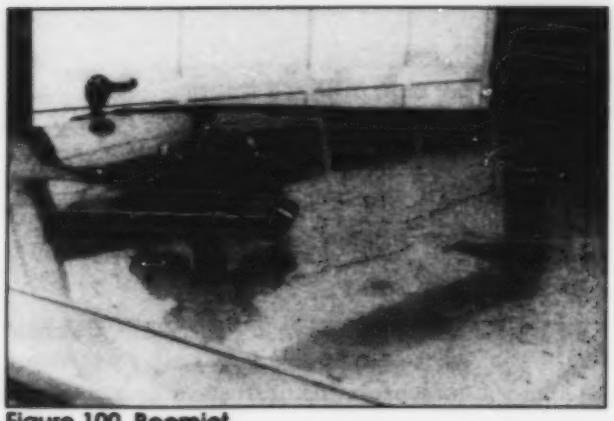

Figure 100. Boomjet

Figure 101. Accutrol V nozzle

the operator. Large V-nozzles are used on a boom and produce a fan-shaped spray pattern (figure 101). Other types of accutrol nozzles are designed for use as a boomless spray system (figure 102). These can also be adapted to handguns (figure 103).

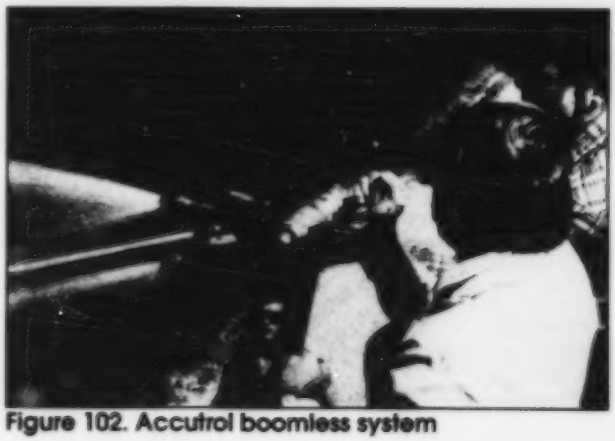

Figure 102. Accutrol boomless system

Radiarc Spray System

The radiarc is a boomless spray system used for industrial spraying such as on roadsides (figure 104). Swath widths can be adjusted from 1 metre up to 7 metres when using the pattern radius. By using the pattern diameter, swath widths up to 12 metres can be obtained. This spraying device

Table 21. 1/4" Off-centre Nozzle Output Table

Nozzle no.	Pressure	Volume	Width	Litres per acre at 45 cm spraying height			
	kPa	L/min	cm	6 km/h	8 km/h	9 km/h	10 km/h
O.C. 02	200	.65	172	15	11	10	9
	300	.79	177	18	14	12	11
O.C. 03	200	.97	195	20	15	13	12
	300	1.18	203	23	17	15	14
O.C. 04	200	1.29	231	22	17	15	13
	300	1.58	236	27	20	18	16
O.C. 06	200	1.93	251	31	23	21	19
	300	2.37	256	38	29	25	23
O.C. 08	200	2.58	254	41	31	27	25
	300	3.16	259	49	37	33	29
O.C. 12	200	3.87	259	60	45	40	36
	300	4.74	264	72	54	48	43
O.C. 16	200	5.16	335	62	47	41	37
	300	6.32	350	72	54	48	43

Table 22. 3/4" Off-centre Nozzle Output Table

Nozzle no.	Pressure kPa	Volume L/min	Width m	Litres per acre at 45 cm spraying height 6 km/h	8 km/h	9 km/h	10 km/h
O.C. 10	200	3.20	5.4	19	17	15	13
	300	3.95	5.6	21	19	17	14
O.C. 20	200	6.45	7.1	28	25	22	19
	300	7.90	7.4	32	28	26	21
O.C. 40	200	12.8	7.9	49	44	39	33
	300	15.8	8.2	58	52	46	39
O.C. 80	200	25.8	8.8	89	79	71	59
	300	31.6	9.1	105	93	84	70
O.C. 150	200	48.3	9.3	158	140	126	105
	300	59.2	9.6	186	165	149	124
O.C. 300	200	96.7	9.7	303	269	242	202
	300	118.0	10.0	364	324	291	243

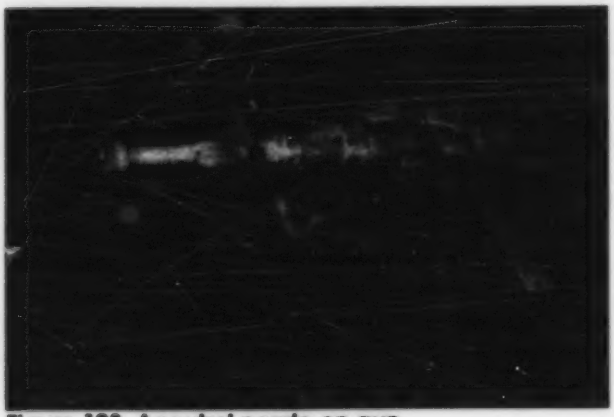

Figure 103. Accutrol nozzle on gun

uses an oscillating motion to produce the spray pattern. Drift control additives can be used with the Radiarc spray system and it can be adapted to computer controlled spray programs.

Controlled Drop Applicators

Electrically or hydraulically driven, spinning disc nozzles use centrifugal force to distribute droplets in a circular hollow-cone spray pattern (figure 105). Droplet size is controlled by rotational speed of the disc and flow volume.

Figure 104. Radiarc spray system

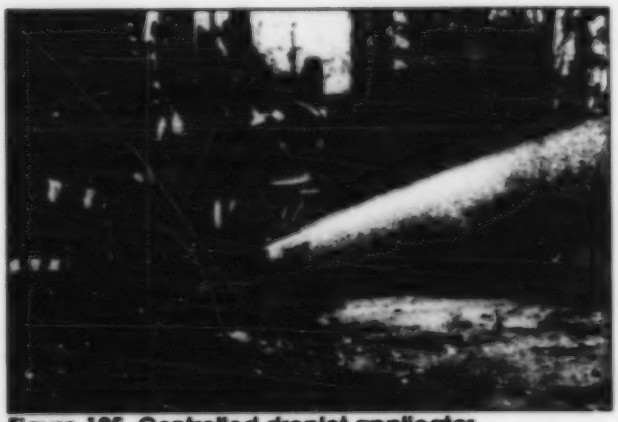

Figure 105. Controlled droplet applicator

Sprayer Calibration

Accurate calibration of spraying equipment is an important aspect of chemical usage. An application of more than the recommended rate is wasteful and may damage the crop; applications of less than the recommended rate may be ineffective.

Preliminary Adjustments and Settings

Preliminary adjustments and settings include all of the adjustments that are made when the machine is being prepared for use.

Before starting to spray, check wheel bearings and tire inflation, and lubricate moving parts as recommended in the operator's manual. Tighten any loose bolts or nuts.

Install tips, screens, check valves, and any other equipment that has been selected. Be sure flat fan nozzles are aligned so patterns overlap slightly but do not interfere with each other.

Boom height depends on the spray angle of the tips selected. Set the boom at the required height and level it from side to side. Improper height causes non-uniform application.

Nozzle Calibration

The output of individual nozzles must be within five per cent of the average nozzle output if an even volume is to be applied over the width of the sprayer. Nozzles with outputs either above or below this value must be cleaned or replaced.

- Check and clean all nozzles, screens and filters.
- Check pressure gauge for accuracy.
- Check boom pressure with an accurate gauge, and compare to sprayer gauge.
- With the sprayer operating at the desired spraying (boom) pressure, using water only, collect nozzle output for 30 seconds. If ball check valves are used, the pressure should be increased by 35 kPa.
- Measure and record collected amount.
- Repeat steps 4 and 5 for all nozzles.
- Replace nozzles that have an output five per cent greater than average; clean and recheck nozzles with outputs of less than five per cent of average (replace if necessary). Replace nozzles when output exceeds 15 per cent of original output.

Calibration Procedure I – Litres Per Acre

Determine area to be sprayed.
Example = 30 acres

Know sprayer tank capacity.
Example = 1400 litres

Determine spray volume (from label*).
Example = 40 L/ac

Select nozzle (Table 23) for 40 L/ac.
Example = 8002 at 275 kPa and 9 km/h

Calculate water volume required.
Example = 30 ac x 40 L/ac = 1200 L

Determine pesticide rate/acre (from label*).
Example = 0.6 L

Calculate amount of pesticide.
Example = 0.6 L x 30 ac = 18 L/ac

Set pressure at 275 kPa, drive at 9 km/h. At this speed it takes 36 seconds to travel 90 metres (table 24).

*Label rates on pesticide containers must be converted to L/acre by multiplying L/hectare x 0.4047.

If spray charts are not available for your nozzles the following formula may be used to establish

their spray volume at a set pressure and speed: [240 x av. nozzle output (L/min)] divided by [ground speed (km/h) x nozzle spacing (m)] = Spray volume per acre (L/ac)

Calibration Procedure II

This method of calibration is provided as an alternative.

After the nozzles have been individually calibrated and matched the following steps should be completed.

Fill sprayer tank with water.

Spray a known distance in the field.

Measure amount of water needed to refill the tank.

Calculate application volume using the following formula: [Litres used x 4047] divided by [Boom width in metres x distance sprayed in metres]= Litres per acre

If the application volume is different than desired, change nozzles or forward speed and repeat the procedure.

Ground Speed Determination

Ground speed can be determined by measuring the distance travelled in one minute. Repeat the test several times and average the results. Remember to use the same throttle setting (tachometer) and transmission gear each time. Run the tests with the sprayer tank half-full. Soil surface and load can affect ground speed and a half-full tank represents the average load. The sprayer must be moving at full speed before starting the test run.

Table 24. Speed Chart

Speed	Seconds to drive	
km/h	60 metres	90 metres
5.0	45	68
5.5	39	58
6.0	37	54
6.5	34	51
7.0	30	45
8.0	27	41
9.0	24	36
10.0	23	34
11.0	19	29
12.0	18	27
13.0	17	25
14.0	15	23
16.0	14	20

Changing Rates

Suppose the application rate you determined is unacceptable. How do you change it? You can make three kinds of changes.

Pressure influences flow rate, as discussed earlier. Lower the pressure and you lower the flow rate. Raise pressure and flow rate is increased; however, this is not a good method to use for large volume changes. You must increase pressure by a factor of four to double the flow. High pressure will increase the number of small spray particles, which can cause drift problems. Pressures that are too high or too low also distort nozzle distribution patterns.

Nozzle size can be changed to alter the application rate. Use larger tips to increase the rate. The main advantage of this method over changing the pressure is that using the proper pressure helps to control drift and maintain the nozzle pattern. This is the preferred method of changing application rates.

Speed changes alter application rate. This method is practical for small changes in application rate. Excessive speeds should be avoided for safety reasons. Low speeds will increase the time needed to spray a given field. This increases labor costs and ties up equipment for a longer period of time.

Calibrating Small Sprayers

The spray volume that a small sprayer will apply per acre can be determined by field testing the sprayer on a portion of an acre.

The size of the test area commonly used is 1/100 of an acre. It is important that the test area surface is similar to the surface to be sprayed so the walking speed will remain the same.

Step 1 Establish a test run distance to spray 1/100 acre (40.5 m^2) according to the swath width of the sprayer.

Swath Width	Test Run Length
0.5 metres	81.0 metres
1.0 metres	40.5 metres
1.5 metres	27.0 metres
2.0 metres	20.2 metres

Step 2 At a comfortable walking speed, spray the test area and measure the volume of water used. (Repeat 2 or 3 times to obtain an average). This is the amount applied to 1/100 acre.
Example = 2 L

Step 3 Multiply the figure arrived at in Step 2 by 100 to get the spray volume per acre.
Example = 2 L x 100 = 200 L/ac

Step 4 Determine amount of pesticide to add per tank load.

Divide the volume applied per acre by tank capacity to determine the number of fills required to spray an acre.
Example = 200 L/ac ÷ 20 L/tank = 10 fills

Divide the chemical rate per acre by the number of tank loads required to spray an acre to determine the amount of product to add per tank load.
Example = 1 L/ac ÷ 10 fills = 0.1 L/tank

Calibrating Sprayer Monitors

Electronic monitoring and control systems correlate liquid flow with travel speed to display the application rate as a continual digital readout. The operator adjusts travel speed and/or spray pressure until the desired application is displayed on the monitor screen. Electronic systems must be installed and calibrated according to instructions in the operator's manual to function properly and accurately.

A fast and simple way to check monitor application rate accuracy is to use a nozzle chart, if the nozzles are new. The application rate, speed and pressure displayed on the monitor should agree with the application rate, speed and pressure in the nozzle chart.

When using electronic systems the operator must choose properly-sized nozzles to spray at or near the desired speeds and pressures. For example, the operator will not obtain 40 L/acre at normal nozzle pressures or speeds if the sprayer is equipped with 20 L/acre nozzles.

The displayed speed should be checked by the procedure outlined in the ground speed determination section. If the measured ground speed does not match the speed displayed on the monitor, the speed sensor should be recalibrated and/or adjusted according to manufacturer's instructions. For greater accuracy the operator should always calibrate the speed sensors under actual field conditions.

Calibrating Handguns

Step 1 Using the same speed and mode of transport that will be used when spraying, spray a test area of known area. Record the elapsed time.
Example = 1000 m^2 Time = 120 seconds

Step 2 For the same amount of time, spray into a suitable container and measure the water collected. This is the same volume sprayed on the test area.
Example = water collected = 25 L

Step 3 Calculate the spray volume Litres sprayed x m^2/ac divided by area sprayed = L/ac
Example = 25 x 4047 ÷ 1000 = 101 L/ac

Step 4 Determine amount of chemical to add to tank. Chemical rate/ac x tank capacity ÷ spray volume
Example= Chemical rate = 1 L/ac
Tank capacity = 3000 L. 1 x 3000 ÷ 101 = 29.7 litres of chemical

Sprayer Operation

Planning a Spraying Operation

Preliminary planning begins with the decision to apply a herbicide and to chose the particular chemical that will be used. You then have three more decisions to make:

- What speed of travel will you use to apply the chemical? This will depend on the kind of equipment you will use and the roughness of the field you want to spray.
- What nozzle tips should you use? You pick the nozzle size that will apply the required volume at the speed you wish to travel using the recommended pressure.
- How much chemical should you apply? The chemical label shows the amount of chemical to apply.

Table 25. Spray Planning Guide

The following guide is provided to help plan a spraying operation.

A. Field description _____

B. Field size _____ acres

C. Crop _____

D. Weeds to control _____

E. Herbicide to use _____

F. Herbicide rate _____ litres or _____ kilograms per acre

G. Spray volume needed _____ litres per acre

H. Total herbicide needed (multiply B x F) _____

I. Sprayer tank size _____ litres

J. Nozzle No. _____ = _____ litres/acre

Pressure _____ kPa

Nozzle output _____ litres per minute

Speed _____ kilometres per hour

K. One tankful will cover (divide I/J) _____ acres

L. Herbicide per tankful (multiply F x K) _____ litres or kilograms

Filling the Sprayer

Water Quality

Avoid using ditch, dugout and slough water as much as possible because this water may contain algae, silt or fine sand particles. The cleaner the water the less sprayer maintenance that is required, because nozzles and strainers are less likely to plug. Dirty water causes rapid pump and nozzle wear. In addition, some chemicals like glyphosate are more effective when used with clean water.

Warning: The tank filler hose should be supplied with an automatic shutoff check valve to prevent the tank solution from siphoning into the water supply when the pump has been shut off. If siphoning occurs, the water supply is unfit for any use.

Contamination of water sources is an inevitable consequence of filling sprayers at wells, sloughs, streams or dugouts. Contaminated water can overflow, siphon or leak back into the water source. Pails can be tipped over or spills on the back of trucks or on sprayer tanks and frames may be washed off into the water source.

The only safe way to prevent contamination is to haul the water to the sprayer in a nurse tank.

Mixing

Mixing the pesticide thoroughly and carefully is one of the most important steps in good sprayer operation:

- Incomplete mixing results in varied application rates.
- Some chemicals can form invert emulsions if mixed improperly. An invert emulsion is a thick, mayonnaise-like mixture that will not spray properly and is very difficult to clean out of a sprayer.
- The operator is most likely to be exposed to dangerous amounts of pesticide during mixing because the material is in a concentrated form. Pesticides can be mixed in the tank or in a premix container. Specific instructions are given on the label of each pesticide. Follow them carefully. Adding chemicals in the wrong sequence can prevent otherwise compatible materials from mixing properly.

To mix some chemicals in the tank, add the pesticide to 1/2 tank of water. Turn on the agitator and mix thoroughly, then finish filling the tank with water. For other materials, agitation must be started before adding pesticide and continued until all chemical/water mix has been used.

If a premix container is used, fill it about one-half full of water then add pesticide. Stir the mixture until it is smooth and uniform, then add it to the water in the sprayer tank. Premixing an emulsifiable concentrate with water to form an emulsion, or premixing a wettable powder with water to form a slurry, and then adding these to a partially-filled, well-agitated spray tank can help reduce mixing problems with some pesticides.

Wettable Powders and Flowables

These formulations are being used by an increasing number of farmers. In some cases, the desired chemicals are only available as wettable powders because of difficulties or expense in making them into liquids. These chemicals are effective; however, application takes special equipment and know-how. The newer models of sprayers will generally apply these formulations without problem, but older sprayers may require extensive modification.

To ensure adequate agitation to keep the pesticide in suspension, a mechanical or hydraulic agitator must be installed in the sprayer tank. The paddle type mechanical agitation is best, but jet agitators are quite satisfactory if pump output is sufficient to provide from three to six litres per minute per 100 litres of tank size in addition to the requirements for applying through the nozzles. Larger tanks will require two or more agitators.

Jet agitators may be equipped with various sizes of orifice discs, depending on the amount of surplus pump capacity. Naturally, the larger orifice sizes provide more agitation, but there is a limit beyond which the pump cannot supply enough pressure. To determine the best size of orifice may require trial and error, although charts are provided with the agitator so that a rough first selection can be made.

To avoid plugging, all strainers in the sprayer system must be of the screen or slotted type and

not finer than 50 mesh. Powders act as a fine abrasive and rapidly erode brass nozzles.

A special procedure for adding wettable powders to the tank should be followed to ensure that the powder goes into suspension, rather than forming lumps. Start by premixing the material with water in a pail. Fill the sprayer tank halfway with water and turn on the agitator. Slowly pour the slurry into the tank. If you are making a tank mix, add the other pesticides, then fill the tank and begin spraying. Do not leave wettable powders standing in the tank. Once they settle to the bottom it will be difficult to get them back into suspension.

Without the proper equipment and procedures, farmers should not use wettable powders as the results will be disappointing and the application a source of frustration.

Note: Do not confuse wettable powders with soluble powders. Soluble powders truly dissolve in water; they do not remain as a suspended solid. They do not require any special handling, other than a little time and agitation to dissolve them.

Field Operation

Transportation to the Field

Transport loaded sprayers as short a distance as possible. A load of chemicals could spill in a ditch or on the road in an accident where it could be hard to contain and cleanup. If agitation of some mixtures is stopped during transport to the field, it may be difficult or impossible to obtain adequate remixing.

Suggested Method of Spraying

Avoid travelling with or against the wind. Avoid travelling in circles. During cornering three things usually occur:

- Part of the corner is missed. Some operators usually spray the corners diagonally after completing the field which is a waste of pesticide.
- Overlapping. It can cause crop damage and/or reduced yields, including the following year if the pesticide persists.
- Parts of the boom travel at different speeds relative to the ground causing varying application rates through the entire width of the boom. In some cases, part of the boom stops or reverses (figure 106) for an instant, which may cause the crop to be burned.

Fields should be sprayed back and forth after spraying around the edge of the field (figure 107). The nozzle flow should be stopped at the headlands to prevent over-application.

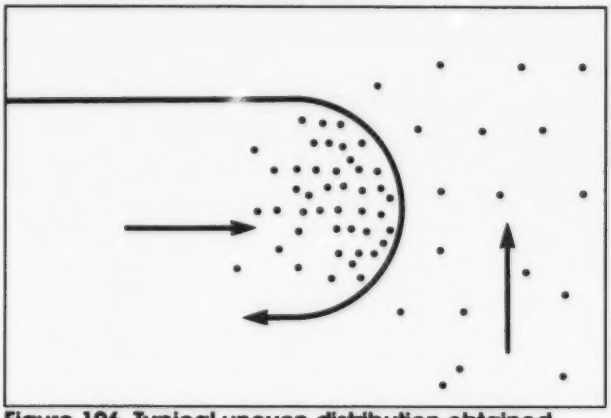

Figure 106. Typical uneven distribution obtained when applicator is not shut off when cornering.

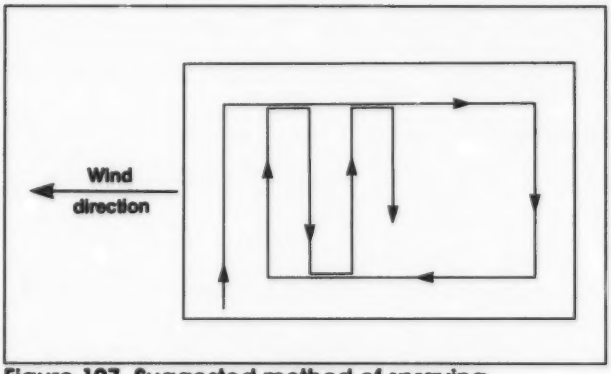

Figure 107. Suggested method of spraying

Using Boom-End Nozzles

The spray pattern produced by end nozzles is erratic and susceptible to drift. Boom-end nozzles should only be used on headlands and ditches and only when it is calm.

Marking Systems

Field markers

Field markers are available to aid the operator in preventing misses and overlaps. The disc marker,

flag marker, foam marker, spot dye marker and paper marker are commercially available. Matching sprayer and seeding equipment width is another convenient way to eliminate overlaps and misses.

Tramlines

Some farmers use tramlines as a field marking system in cereal and oilseed crops (figure 108).

The principle of tramlines is to match the working widths of sprayers with that of the seed drill so that spraying operations can be carried out along the tracks laid while seeding. The working width of the seed drill must first be established and then related to the width of the sprayer boom. The boom may need shortening or lengthening so that a multiple of drill passes matches one pass of the sprayer, thus enabling the tramlines to be placed at appropriate intervals.

Block a single drill run which is one-half the width of the tractor track from the end of the drill (figure 109). This puts in one tramline going up the field and another coming back. This system works well if spraying equipment is twice the width or four times the width of the seeder.

Other methods of producing tramlines can be used; however, the one described here is the simplest to implement.

Indications are that any potential yield losses when using tramlines are compensated for as follows:

- rows that are adjacent to the tramline can draw on extra moisture and soil nutrients and produce more seed.

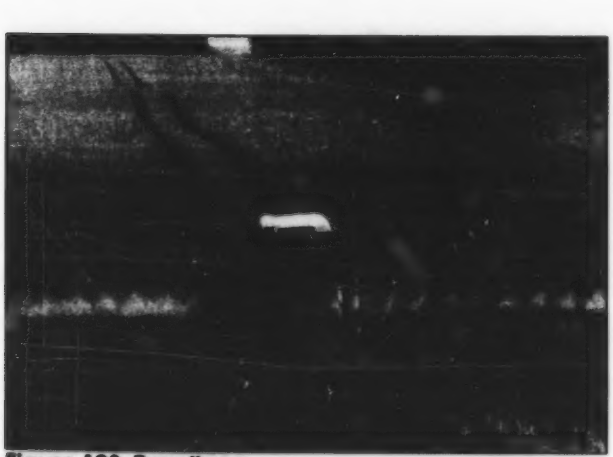

Figure 108. Tramlines

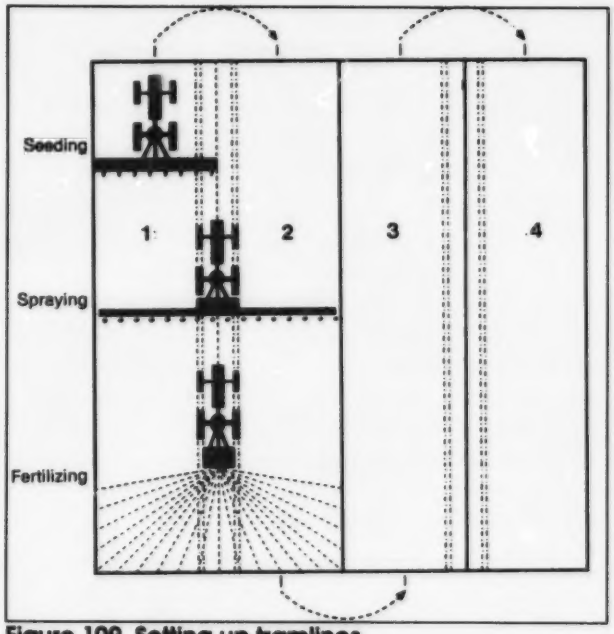

Figure 109. Setting up tramlines

- more accurate chemical placement without double coverage or missed strips creates potential for increased yields.
- trampling from tractor wheels creates some yield loss even if tramlines are not used.

Spray pattern indicator

Spot spraying weeds or brush presents a problem to the applicator of not knowing if any areas are being missed. Starting or stopping points on partially completed areas such as in roadside spraying can be difficult to detect.

A special coloring agent can be added to the spray solution that will give sprayed foliage a darker green appearance. When sprayed onto gravel, the coloring agent appears blue. This feature helps the applicator to see a spray application is being done accurately. It also makes it easier to detect spray drift and operator exposure to the drift. Depending on the strength of solution used, water will dissipate the color immediately and sunlight will break down the color in a few days. This product is not intended to be used on a crop.

Table 26. Trouble shooting sprayers

Problem	Possible Cause	Remedy
Loss of pressure	Pressure regulator is improperly adjusted or stuck open.	Clean and adjust pressure regulator.
	Suction screen is plugged.	Thoroughly clean screen.
	Suction hose is cracked or porous.	Replace hose.
	Worn pump.	Replace or recondition pump according to the manufacturer's instructions.
	Nozzle tips are worn.	Replace nozzle tips
	Gauges is faulty.	Replace gauge.
	Pump is starving.	Check for collapsed suction hose, plugged filter, main control valve too small or wrong type.
Excessive pressure	Pressure regulator is improperly set.	Adjust pressure regulator.
	Bypass hose is plugged or too smal	Unplug the hose or replace it with a larger one.
	Gauge is faulty.	Replace gauge.
Pressure gauge needle jumps excessively.	Gauge is too sensitive.	Replace gauge or mount a flow regulator between the gauge and the pump.
	Pump is starving.	Check for restriction on inlet side of pump.
Nozzles plugging	Nozzle screen is too fine or the screen is corroded	Replace with the proper mesh screen or clean the screen thoroughly.
	Dirty water or foreign material is in the tank.	Drain tank and clean thoroughly; check suction screen for holes.
	Pesticide(wettable powder) is not properly mixed.	Increase agitation.
	Nozzles are too small.	Replace with the proper nozzles for the chemical being used.
	Boom is filled with foreign material.	Remove the plugs in the ends of the boom section to clean the boom.
Poor spray patterns	Booms is too low.	Raise boom, or rotate ahead or back slightly.
	Pressure is too low.	Check pressure on boom end with a gauge. Pressure should be within 10 to 15 kPa of main gauge. If not, check sizes of fittings and hoses for restrictions.
	Nozzles are worn or damaged.	Replace nozzles.
Uneven spray pattern	Nozzle screen is plugged.	Clean or replace screen.
	Nozzle tip is damaged.	Replace tip with new one.
Visible spray drift	Spray is too fine.	Reduce pressure, use larger nozzles.
	Boom is set too high.	Lower boom and angle forward or back.
	It is too windy.	Quit spraying.
Booms swinging	Hitch between sprayer and tractor is loose.	Tighten hitch or use ball type hitch.
	There are no braces.	Install horizontal braces on boom.
Booms moving up and down	There are no boom wheels.	Install boom wheels.
	Field is rough.	Slow down.

Granular Application

Granular herbicides must be applied uniformly on the entire field. Granular herbicides do not diffuse more than one centimetre into the soil. If they are not applied uniformly this can lead to areas of no control and other areas where the crop is injured.

The rate of application is critical to the extent that an under application of 20 per cent can lead to only 50 per cent control. Also an over application by 20 per cent can become fairly expensive not only in dollars paid for the herbicide, but because over application may cause residues to persist into the following year causing crop injury.

The most efficient method of applying granular herbicide is with an applicator mounted on a tillage implement. It saves money by providing application and incorporation in one trip over the field, and it also provides an accurate marker system to avoid doubling over a treated area.

A marker system is important in any herbicide application, but it can be critical when applying the residual granular herbicides that are commonly used. For example a two-foot overlap using a 40-foot machine will cause five per cent of a field to be covered twice. If a product costs $13 per acre at the recommended rate, a waste of 65¢ per acre occurs. Add to this the yield reduction in

Types of Applicators

Many types of granular applicators are available on the market today. Gravity and pneumatic applicators in implement-mounted, skid-mounted and pull-type trailer models are common (figure 110). Some have electronic monitoring devices and others have automatic electronic rate controllers. Pneumatic applicators seem to be taking over from the gravity-type machines, especially the implement-mounted type for wide, multi-winged, tillage equipment (figure 111). Rental agencies and custom applicators use trailer-type and skid-mounted pneumatic applicators almost exclusively.

Figure 110. Gravity applicator

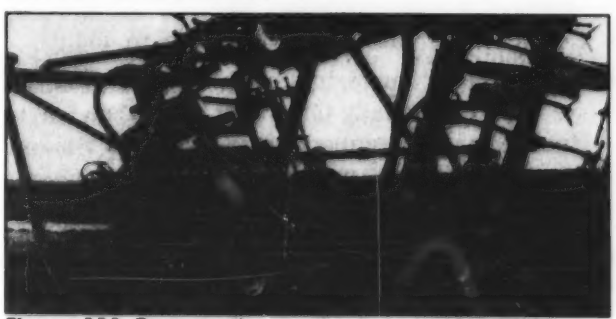

Figure 111. Pneumatic applicator – implement mounted

Operation

Regardless of which type of granular applicator is used there are some constant "Do's and Don'ts" to keep in mind to achieve as uniform an application as possible. Keep in mind that even the most thorough incorporating job will not improve a poor job of applying the herbicide.

the current year plus damage to the crop the following year because of residue carry over.

Trailer-type and skid-mounted applicators have marking systems available as options. Markers include foam markers, paint markers and disc markers; however, many rental units do not have any marker system.

Maintenance and Precautions

A continuous check on the calibration of all granular applicators is necessary because flowability of granules changes with temperature and humidity. High temperature and/or humidity cause granules to become sticky and to not flow uniformly. Granular herbicides should be stored in a cool and dry place out of the sunlight. They should never be left in the hopper overnight because moisture can cause the granules to form a crust and plug the metering devices. Left over chemical should always be removed from the entire system. Granular herbicides should be screened to separate out lumpy herbicide that would affect metering. The lid on hopper boxes must be kept closed to prevent moisture or debris from entering.

The following checklist summarizes the maintenance activities necessary to obtain the best results and durability from airflow granular applicators:

- Inspect and clean – hopper bottom, feed metering rollers, venturies and hoses should be checked at least once daily to ensure that they are free of moisture, dust, chaff, stones, etc.
- Airflow hoses – check daily for wear. Turn hoses 90° yearly, to extend life.
- Lubricate – grease all moving parts frequently.
- Electric clutch/metering drive/feed metering system – check daily for proper operation. Ensure that all components of the metering assembly are tight and in line.
- Fan Inlet – ensure that it is free and clear of all obstructions.
- Fan Belt – check for wear.
- Ground drive only – check tire pressure because it can affect rate of application.
- Fan Drives –

  Auxiliary gas engines - check oil and air filter daily. Ensure fan speed of 3,000 to 3,600 rpm.

  PTO Drive (NODET®) – operate with 540 or 1,000 rpm PTO. The 1,000 rpm PTO requires adapter kit, to produce a fan speed of 3,600 to 4,000 rpm.

  Hydraulic Motor

Applicator Model	hydraulic flow gpm	Fan speed rpm
Beline Computaire®	10	2,900
Gandy Air-speed®	8	4,000
Valmar Airflow®	10 - 12	3,000 – 3,600

- Wet Equipment – after heavy dew or rain, clean hopper bottom and feed metering rollers and run fan about 15 minutes to dry out hoses and venturi system.
- Outlet uniformity – before loading hopper, inspect for obstruction in the airflow system by checking air velocity at all outlets.
- Marking system – for trailer type or truck-mounted applicators, especially in stubble conditions, a sturdy disc-type marker or a properly operating foam marker is necessary for accurate application.
- Hopper screen – be sure to load product through the hopper screen to prevent foreign material (paper, dirt, straw, etc.) from entering and plugging or damaging the metering system.
- Application delays – to prevent moisture absorption and caking, avoid letting product remain in the applicator overnight or for other prolonged periods of time, especially during high temperatures and excessive moisture.
- Calibrate – frequent calibration is necessary to ensure accurate and consistent rates of application. Rate charts and calibration instructions are available from the applicator manufacturer.

Calibration

Correct calibration of granular applicators is essential for accurate herbicide application. The operator's manual for each granular applicator contains information on procedures to follow for correct calibration settings and how to check the calibration. When renting an applicator, ensure that an operator's manual is made available. It is critical that granular applicators are calibrated for the particular granule size to be applied. This is extremely important when renting a unit because the previous renter may have calibrated it for some other product.

1. Fill the hopper(s) to a pre-determined level.
2. Treat an area of known dimension.
3. Weigh a full bag.
4. Refill the hopper(s) from the bag to the original level in the applicator.
5. Weigh the remainder left in the bag.
6. Calculate the amount used by subtracting the weight of the remainder from the weight of the full bag.
7. Divide this by the area treated to determine the rate per acre.
8. Adjust the gauge setting if necessary.

Preparing for Storage

Take the following steps before storing equipment:

- vacuum or blow out the applicator
- cover the applicator with a tarp, don't store in direct sunlight
- remove chains, metering devices and control boxes and store them indoors.
- cover electric clutches with a plastic bag.

Soil Incorporation

Soil-applied herbicides have varying requirements as to depth of incorporation. The crop being grown, the weeds to be controlled, and the herbicide being used dictate just how deep the incorporation must be to achieve maximum weed control with minimum crop damage. For example, trifluralin is incorporated to a depth of 10 centimetres to control wild oats in a canola crop but is only incorporated to a depth of 4 cm when used to control green foxtail in cereals. If the trifluralin were incorporated deeper than 4 cm in the case of cereals, the crop would be severely damaged and the herbicide concentration would be diluted in the soil profile providing poor green foxtail control.

For the above reasons it is especially important that any granular herbicide which calls for a shallow incorporation should not be applied to lumpy soil because the granules may drop between the lumps to a greater depth than required, whereas a liquid spray is attached to the soil particles. If granules are to be used on this type of soil, it is necessary to pre-work the soil, so that it is free of large lumps, before applying the herbicide. If several tillage operations are required to achieve the proper soil condition for good incorporation of the granular herbicide, the soil may dry-out, as well as create a situation where the soil would be subject to wind and water erosion. Therefore, if the recommended incorporation procedure increases the erosion potential, an alternate herbicide or weed control method should be considered.

High levels of crop residue or plant growth on the soil surface affect the activity of soil-incorporated liquid herbicides because of the herbicide being absorbed by the trash. A general recommendation is to reduce crop residue and plant growth in stubble fields so that two-thirds of the soil surface is visible before applying a liquid soil incorporated herbicide. In areas where soil drifting may be a problem, excessive cultivation to prepare the soil for a liquid herbicide should be avoided.

Granular soil-incorporated herbicides were introduced to improve herbicide performance in situations where there were large amounts of straw on the soil. Granules can be applied directly to stubble before tillage operations, providing there is not too much straw or chaff to impede uniform incorporation of the herbicide. Because fewer workings of the soil leave more crop residue to prevent soil drifting, granular herbicides are recommended over liquid ones.

Incorporation Equipment

A wide variety of tillage equipment may be used for incorporation of granular herbicides. The choice depends on availability of equipment, soil condition, soil erosion potential, and depth of incorporation required.

Disc-type implements generally provide deeper incorporation, more soil breakdown and more uniform mixing to the depth of tillage than most other implements. This type of implement would be used where deep incorporation is needed, and where the soil is sticky or lumpy. However, where two passes are recommended for thorough and uniform herbicide distribution, and the area is subject to soil drifting, perhaps other equipment would be more suitable.

Cultivators tend to give shallower incorporation than disc implements. Cultivators with rigid shanks, wide shank spacing, and low lift sweeps can be expected to provide poor uniformity of incorporation and an uneven incorporation depth, especially at slower speeds. Cultivators with flexible shanks, narrow shank spacing and high lift sweeps provide more uniform incorporation when used at high speeds of travel; however, the incorporation is shallower.

Harrows are used for shallow incorporation, but soil must be loose or else incorporation will be too shallow. Tine harrows behind cultivators tend to provide more mixing than drag harrows owing to the movement of the tines. Rotary or oscillating harrows are more effective in heavier trash conditions because they do not tend to plug up.

In general, increased speed of operation will improve soil mixing and at the same time increase the risk of soil erosion.

Rod weeders and other wide blade implements do not provide good incorporation of soil-applied herbicides because very little soil is disturbed and most of the granules are left on or near the surface.

Although there are many factors to consider when selecting a method for incorporating soil-applied herbicides, close attention must be paid to herbicide label recommendations concerning application and incorporation techniques. A careful check on soil conditions is needed to avoid drying out the soil and to avoid increasing the potential for soil erosion. Cultivated soil that is likely to dry out should be harrowed and packed after any tillage operation, be it spring or fall.

Reading and following label instructions will ensure best results unless conditions are extreme.

Seed Treatment Applicators

A variety of large commercial seed treating machines are in common use. Many growers prefer to buy pre-treated seed in bulk or in bags. The cost of this service is insignificant when compared to the convenience that results. Seed cleaning plants, seed growers and seed retailers also treat on demand for growers with purchased seed or their own seed. This has become a standard practice with canola and mustard seed and is more readily available than ever before with cereals.

For treating cereals a number of inexpensive auger treaters are available for on-farm use. The drip applicator is still preferred by many growers (figure 112).

Because drip-type applicators depend on gravity to operate, the rate of flow changes as the level of liquid in the containerchanges thus necessitating adjustments to compensate for the changing flow rate. Temperature changes affect the viscosity of liquid chemicals causing them to flow at a slower rate when cold and a higher rate when warm, thereby making it difficult to maintain a constant flow with gravity-type drip applicators.

The Vitavax applicator is another seed treater that meters chemical into the bottom of a drill fill auger thus treating seed on demand (figure 113). This practice takes only a few more minutes when filling the seed drill and offers the advantages of minimal contamination of equipment and no extra treated seed to be concerned about.

Larger capacity applicators with optional attachments make it possible to apply two or more formulations simultaneously regardless of whether they are fungicides, insecticides, flowables, slurries, powders or solutions.

Drill fill powders continue to be available for treating seed in the drill. This is often used to quickly handle the tail end of a field after pre-treated seed is used up. Some growers prefer using this method of seed treatment.

Figure 112. Drip applicator

Figure 113. Vitavax applicator